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NOTES ON THE LIGNEOUS PLANTS DESCRIBED BY LEVEILLE FROM EASTERN ASIA[1]

ALFRED REHDER

CELASTRACEAE (Supplement)

Tripterygium hypoglaucum (Lévl.) Hutchinson in Kew Bull. Misc. Inform. 1917, p. 101. — Léveillé, China Rev. Ann. 1916, p. 23 (Msc.). — Loesener in Ber. Deutsch. Bot. Ges. LA, p. 10 (1932).

Add as synonym:

Microrhamnus Franchetiana Léveillé in Bull. Géog. Bot. XXV. 26 (1915), excl. descript. fructus; Cat. Pl. Yun-Nan 227 (1917). — **Synon. nov.**

CHINA. K w e i c h o u : Brousses des montagnes à Siao-ou-long, 2600 m., *E. E. Maire,* June 1912, "arbuste grimpant à long rameaux, fl. blanches" (holotype of *Microrhamnus Franchetiana,* excl. fruiting branch; photo. and merotype in A. A.).

In revising Léveillé's Rhamnaceae I found that his *Microrhamnus Franchetiana* belongs only partly to the Rhamnaceae, while the flowering branch upon which the description chiefly is based, is to be referred to *Tripterygium hypoglaucum.* The leafless fruiting branch represents *Berchemia Giraldiana* Schneid.

STAPHYLEACEAE

Staphylea holocarpa Hemsley in Kew Bull. Misc. Inform. 1895, p. 15. — Léveillé, Cat. Pl. Yun-Nan, 267 (1917).

Xanthoceras enkianthiflora Léveillé in Fedde, Rep. Spec. Nov. XII. 534 (1913); Fl. Kouy-Tchéou, 384 (1915) "Zanthoceras." — **Synon. nov.**

Tecoma Cavaleriei Léveillé, Fl. Kouy-Tchéou, 50 (1914). — **Synon. nov.**

[1]Continued from Vol. XIV. 252; for preceding parts see Vol. X. 108-132, 184-196; Vol. XII. 275-281, and Vol. XIII. 299-332.

CHINA. K w e i c h o u : Tou-chan, *E. Bodinier,* April 1900 (ex Léveillé; holotype of *Xanthoceras enkianthiflora*); Gan-chouen, *J. Cavalerie,* no. 3913, April 1912 (sub *Zanthoceras enkianthiflora* in Fl. Kouy-Tchéou, l. c.; duplicate in A. A.); nord de Gan-chouen, *J. Cavalerie,* no. 3913, May 1912 (holotype of *Tecoma Cavaleriei;* merotype in A. A.).

The type of *Xanthoceras enkianthiflora* is missing from the Léveillé herbarium, but I have before me the additional specimen cited in Flore de Kouy-Tchéou and an unnumbered specimen collected by Cavalerie with a label not in Léveillé's handwriting, giving a different locality but the same date. The flowers, however, instead of being 3-4 times larger than *Xanthoceras sorbifolia* as stated in Léveillé's description, are really smaller, and I cannot reconcile this part of the description with the specimens before me. The type of *Tecoma Cavaleriei* is in fruit and Léveillé apparently took the thin capsule, splitting at the apex into several lobes, for a flower.

Euscaphis japonica (Thbg.) Dippel, Laubholzk. 480 (1892).

Evodia Chaffanjoni Léveillé in Fedde, Rep. Spec. Nov. XIII. 265 (1914); Fl. Kouy-Tchéou, 375 (1915). — **Synon. nov.**

Euscaphis staphyleoides Siebold & Zuccarini, Fl. Jap. I. 125, t. 67 (1835). — Léveillé, Cat. Pl. Yun-Nan, 267 (1917).

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège, *J. Chaffanjon* in herb. *Bodinier,* no. 2263, April 15, 1898 (holotype of *Evodia Chaffanjoni;* merotype in A. A.).

ICACINACEAE

Iodes ovalis Blume, Bijdr. 30 (1825). — Baillon in De Candolle, Prodr. XVII. 22 (1873).

Iodes vitiginea (Hce.) Hemsley in Jour. Linn. Soc. XXIII. 115 (1886).

Vitis chrysobotrys Léveillé & Vaniot in Fedde, Rep. Spec. Nov. III. 350 (1907). — **Synon. nov.**

Vitis Seguini Léveillé, Fl. Kouy-Tchéou, 28 (1914), pro parte, quoad Esquirol, nos. 508 and 868; non Léveillé (1907).

Sabia edulis Léveillé, Fl. Kouy-Tchéou, 379 (1915), nomen; pro parte, quoad Cavalerie, nos. 2033, 3904. — **Synon. nov.**

Hernandia sinensis Léveillé, Fl. Kouy-Tchéou, 379 (1915), pro synon. *Sabiæ edulis.*

CHINA. K w e i c h o u : without precise locality, *J. Esquirol,* no. 508, June 1905, "fleurs verdâtres" (holotype of *Vitis chrysobotrys;* photo. in A. A.); près fleuve Houa-kiang, *J. Cavalerie,* no. 2033, June 6, 1904 (syntype of *Sabia edulis;* photo. in A. A.); without precise locality, *J. Cavalerie,* no. 3904, in 1912 (syntype of *Sabia edulis;* photo.

in A. A.); without precise locality, *J. Esquirol,* no. 868 (sub "*Sabia edulis* [*Vitis chrysobotrys* Lévl. & Vant.]" in herb. Léveillé; sub *Vitis Seguini* in Fl. Kouy-Tchéou; dupl. in A. A.).

Sabia edulis was published as "comb. nov." without description, only with the citation *Hernandia sinensis* Lévl. as a synonym, but that name is only a manuscript name and appears on the sheet of Cavalerie's no. 2033 with a Latin description and a pencil-note in Léveillé's handwriting "non publ." The name *Sabia edulis* is not found on this sheet nor on the sheets of the other two numbers. *Vitis chrysobotrys* is referred by Léveillé to *Vitis Seguini* as a synonym in his Flore de Kouy-Tchéou (p. 28), but in his herbarium it is given under Esquirol, no. 868, as a synonym of *Sabia edulis.*

I am unable to separate *I. vitiginea* clearly from *I. ovalis* Bl. which is apparently a very variable species of wide distribution. By Gagnepain (in Lecomte, Fl. Gén. Indochine, 1. 845. 1911) *I. vitiginea* is made a variety of *I. ovalis,* but the distinguishing characters given—plant less pubescent, leaves very pale beneath—do not seem to distinguish the plant from the type which is described by Baillon (l. c.), as with "foliis . . . parce villosis" in contrast to the tomentose var. *Miquelii.* I have seen no spontaneous specimen from Java except one from a plant cultivated in Buitenzorg (Hochreutiner, Pl. Bogor. Exsicc. no. 427) which seems referable to var. *Miquelii.* I prefer, therefore, for the present to accept *I. ovalis* Bl. in the wide sense of most modern authors.

As the author of *I. vitiginea* usually Hance is cited, but he did not publish the combination. In 1873 (Jour. Bot. XI. 266) he described *Erythrostaphyle vitiginea* as a new genus and new species of Verbenaceae. In the following year he published a note (Jour. Bot. XII. 184) saying that Professor Oliver had pointed out to him that the plant described under the above name is a species of *Iodes* closely allied to the Sumatran *I. tomentella* Miq. Hance did not make a new combination and leaves us in doubt, whether he considered it referable to *I. tomentella* or a new species. Hemsley seems to have been the first to publish the combination *I. vitiginea* crediting it to Hance; it does not appear in Index Kewensis except as a reference from *Erythrostaphyle vitiginea,* but under *Iodes* there is no *I. vitiginea.*

Iodes Seguini (Lévl.), comb. nov.

Vitis Seguini Léveillé in Fedde, Rep. Spec. Nov. IV. 331 (1907); Fl. Kouy-Tchéou, 28 (1914), pro parte, synon. et speciminibus Esquirolii exclusis.

Sabia edulis Léveillé, Fl. Kouy-Tchéou, 379 (1915) pro parte, quoad specim. Cavalerie, no. 3932. — **Synon. nov.**

Iodes rugosa Gagnepain in Lecomte, Not. Syst. I. 201 (1910). — Léveillé, Fl. Kouy-Tchéou, 291 (1914). — **Synon. nov.**

Iodes vitiginea var. *levitestis* Handel-Mazzetti in Anz. Akad. Wiss. Wien, 1921, p. 149 (Pl. Nov. Sin. Forts. 12, p. 6) (1921). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Hoang-ko-chan, rocailles de la cascade, *J. Seguin* in herb. *Bodinier,* no. 2614, March 29, 1899, "liane s'attachant aux rochers comme un lierre" (holotype of *Vitis Seguini* [Hb. Léveillé; photo. in A. A.] and of *Iodes rugosa* [Hb. Paris]; route de Tchen-fong à Hin-y-fou, rochers, *J. Cavalerie,* no. 3932, June 1912, "liane aux fruits roses mangeables"; (syntype of *Sabia edulis;* photo. in A. A.); ad viam Tschenning—Huang-tsauba in convalle flum. Hoadjiau-ho infra vicum Tingdaoyin, *Handel-Mazzetti,* no. 10374, June 20, 1917, "fr. rubri, sapore dulci sed paululum amygdalos amaros admonente" (syntype of *I. vitiginea* var. *levitestis;* isotype in A. A.).

Vitis Seguini and *Iodes rugosa* are based on duplicates of the same collection, but Léveillé cites "Seguin, no. 2614" while Gagnepain cites "no. 2614 (Bodinier)," and in his Flore de Kouy-Tchéou Léveillé enumerates both species and cites the same number with different collectors under each. Cavalerie no. 3932 agrees with *I. Seguini,* but the leaves are not deeply cordate and not as strongly veined though distinctly reticulate above which distinguishes them from *I. ovalis.* Handel-Mazzetti's no. 10374 is similar, but the stems are only sparingly verruculose and the leaves are as in Cavalerie's specimen rounded or subcordate at base, not deeply cordate as in the type of *I. Seguini.* The fruits of both specimens are identical and are described as edible and rose-colored or red; they are oblong, 1.8-2 cm. long and about 12 mm. wide, the putamen with a thin and smooth testa. All the specimens cited above agree in the more or less verruculose branches, in the leaves being more strongly veined and reticulate above and in the short inflorescence branched near or at the base, characters by which this species can be readily distinguished from *I. ovalis.*

ACERACEAE

Dipteronia sinensis Oliver in Hooker, Ic. Pl. XXIX. t. 1898 (1889).

Acer Dielsii Léveillé in Fedde, Rep. Spec. Nov. x. 432 (1912); Fl. Kouy-Tchéou, 383 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie,* no. 1097, June 1903 (holotype of *Acer Dielsii;* fragments in A. A.).

Acer Miyabei Maximowicz in Bull. Acad. Sci. St. Pétersb. XXXII. 485 (1888); in Mél. Biol. XII. 725 (1888). — Koidzumi in Jour. Coll. Sci. Tokyo, XXXII, art. 1, p. 57, t. 31 (1911).

Acer Hayatae Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 590 (1906).

JAPAN. H o k k a i d o : near Nanai, *U. Faurie,* no. 6086, June 1904 (holotype; photo. and isotype in A. A.).

Acer Hayatae has already been identified with *A. Miyabei* by Koidzumi (l. c.).

Acer pictum Thunberg, Fl. Jap. 161 (1784).

Acer Hayatae var. *glabra* Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 590 (1906). — **Synon. nov.**

JAPAN. H o n d o : near Aomori, *U. Faurie,* no. 5020; May 20, 1902 (holotype; photo. in A. A.).

Acer pictum f. **tricuspis** Rehder in Mitteil. Deutsch. Dendr. Ges. XXII. 258 (1913).

Acer Bodinieri Léveillé in Fedde, Rep. Spec. Nov. x. 433 (1912); Fl. Kouy-Tchéou, 382 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Tsin-gay, Kao-po, *J. Cavalerie,* no. 1162, July 1903 (holotype; photo. in A. A.).

The specimen differs from the type of this form in the larger leaves with rounded base and in the wings of the fruit spreading at a right or even acute angle; in the rounded base of the leaves it comes near Harry Smith, no. 6551, from Shansi, but that plant has much smaller leaves and wings spreading at a wide angle. In shape the leaves resemble those of *A. Wilsoni* Rehd., but this has a paniculate inflorescence and 3-nerved leaves with different venation.

Acer caudatum Wall. var. **ukurunduense** (Maxim.) Rehder in Sargent, Trees & Shrubs, I. 164, t. 82 (1905); II. 26 (1907).

Acer lasiocarpum Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 591 (1906).

Acer spicatum Lam. var. *ukurunduense* Maximowicz, in Mém. Div. Sav. Acad. Sci. St. Pétersb. IX. 65 (Prim. Fl. Amur.) (1859). — Koidzumi in Jour. Coll. Sci. Tokyo, XXXII. art. 1, p. 31 (1911).

JAPAN. H o n d o : in sylvis Takayu, *U. Faurie,* no. 6102, June 1904 (syntype of *A. lasiocarpum;* isotype in A. A.); in Jizogatake, *U. Faurie,* no. 5467, July 1903 (syntype of *A. lasiocarpum;* photo. in A. A.); in Hakkoda, *U. Faurie,* no. 6100, Aug. 1904 (syntype of *A. lasiocarpum;* isotype in A. A.); in sylvis Ochiai, *U. Faurie,* no. 6101, Sept. 1904 (syntype of *A. lasiocarpum;* isotype in A. A.).

Acer lasiocarpum was first identified with *A. caudatum* var. *ukurunduense* by the writer (op. cit. II. 26).

Acer oblongum Wallich apud De Candolle, Prodr. I. 593 (1824).

Acer Paxii Franch. var. *integrifolia* Léveillé, Fl. Kouy-Tchéou, 383 (1915), nomen. — **Synon. nov.**

CHINA. K w e i c h o u : route de Pin-yue à Kouy-yang, *L. Martin* in hb. *Bodinier*, no. 2618, May 18, 1899, "arbre" (holotype of *A. Paxii* var. *integrifolia;* photo. in A. A.).

I have not been able to find an earlier publication of Léveillé's name except that in Flore de Kouy-Tchéou where it appears as a nomen nudum.

Acer oblongum var. **biauritum** W. W. Smith in Notes Bot. Gard. Edinb. VIII. 329 (1915). — Metcalf in Lingnan Sci. Jour. XI. 195 (1932).

Acer oblongum var. *erythrocarpum* Léveillé, Cat. Pl. Yun-Nan, 252 (1917).

CHINA. Y u n n a n : valleys in the mountains of the Chungtien plateau, alt. 10000 ft., *G. Forrest*, no. 10644, July 1913 (holotype of *A. oblongum* var. *biauritum;* isotype in A. A.); brousse de Mahong, alt. 2800 m., *E. E. Maire*, May [1910-12], "petite arbre, fruit rougeâtre" (holotype of *A. oblongum* var. *erythrocarpum;* merotype in A. A.).

The type of *A. oblongum* var. *biauritum* has mature fruits of light grayish yellow color, while the young fruits of Maire's specimen are purplish and so are the fruits of Simeon Ten, no. 471, the only other specimen with young fruits in this herbarium.

Acer coriaceifolium Léveillé in Fedde, Rep. Spec. Nov. X. 433 (1912); Fl. Kouy-Tchéou, 383 (1915); *"coriaceifolia"* — Metcalf in Lingnan Sci. Jour. XI. 198 (1932).

CHINA. K w e i c h o u : Pin-fa, bois, *J. Cavalerie*, no. 3100, July 2, 1907 (holotype; merotype in A. A.).

By Fang (in Contrib. Biol. Lab. Sci. Soc. China, VII. 167, 1932) the species was referred as a synonym to *A. oblongum* Wall., but it is easily distinguished by the green tomentulose under side of the oblong-lanceolate leaves. It is, as Metcalf points out more closely related to *A. lanceolatum* Molliard than to *A. oblongum*.

Acer Fabri Hance var. **rubrocarpum** Metcalf in Lingnan Sci. Jour. XI. 206 (1932).

Acer Fargesii Franchet apud Rehder in Sargent, Trees & Shrubs, I. 180 (1905).

Acer Prainii Léveillé in Fedde, Rep. Spec. Nov. X. 432 (1912).

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie*, nos. 951, March 1903, and 1048, June 3, 1903 (two syntypes of *A. Prainii;* dupl. and photo. of no. 951 and photo. of no. 1048 in A. A.); Ma-jo, *J. Cavalerie*, July 1903 (ex Léveillé; syntype of *A. Prainii*).

After having seen a fragment of Hance's type of *A. Fabri* I am con-

vinced that it does not belong to *A. laevigatum* Wall. where I had placed it formerly (in Sargent, Trees & Shrubs, I. 180), but that it is conspecific with *A. Fargesi* which represents a red-fruited form of it. *Acer Fargesii* was based by the writer exclusively on red-fruited or red-flowered specimens; of the Farges specimens named by Franchet *A. Fargesi* in herb. the writer saw and cited only a flowering specimen with the flowers and young leaves deep red which obviously belongs to the red-fruited form; the specimen with whitish fruits also named *A. Fargesi* by Franchet was not cited and did not enter in the description, therefore *A. Fargesi* must be considered a red-fruited form of *A. Fabri* and becomes a synonym of *A. Fabri* var. *rubrocarpum* and need not be cited in part under the type. *Acer Prainii* was first identified with *A. Fabri* var. *rubrocarpum* by Metcalf.

Acer Davidi Franchet in Nouv. Arch. Mus. Paris, sér. 2, VIII. 212 (Pl. David. II. 30) (1884). — Léveillé, Cat. Pl. Yun-Nan, 252 (1917). — Fang in Contrib. Biol. Lab. Sci. Soc. China, VII. 174 (1932). — Rehder in Jour. Arnold Arb. XIV. 213 (1933).

Acer Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. x. 432 (1911); Fl. Kouy-Tchéou, 383 (1915).

CHINA. Kweichou: Ma-jo, J. Cavalerie, no. 3345, Sept. 1908 (holotype of *A. Cavaleriei;* merotype in A. A.).

Acer Cavaleriei was first identified with *A. Davidi* by Fang (l. c.).

Acer crataegifolium Siebold & Zuccarini in Abh. Akad. Muench. IV. pt. ii. 155 (Fl. Jap. Fam. Nat. I. 47) (1845). — Koidzumi in Jour. Coll. Sci. Tokyo, XXXII. art. 1, p. 13 (1911).

Acer cucullobracteatum Léveillé in Bull. Soc. Bot. France, LIII. 590 (1906).

JAPAN. Hondo: in sylvis Hayachine, *U. Faurie*, no. 6732, June 5, 1905 (holotype of *A. cucullobracteatum;* photo. in A. A.).

Acer cucullobracteatum was first identified with *A. crataegifolium* by Koidzumi (l. c.). *Acer crataegifolius* [sic] as enumerated by Léveillé in his Flore de Kouy-tchéou (p. 383) and in his Catalogue des plantes de Yun-Nan (p. 252) refers probably to *A. Davidi* of which specimens were found in Herb. Léveillé in the cover of *A. crataegifolium*.

Acer Tschonoskii Maximowicz in Bull. Acad. Sci. St. Pétersb. XXXI. 24 (1886); in Mél. Biol. XII. 432 (1886). — Rehder in Sargent, Trees & Shrubs, II. 26 (1907). — Koidzumi in Jour. Coll. Sci. Tokyo, XXXII. art. 1, p. 24 (1911).

Acer pellucidobracteatum Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 592 (1906).

JAPAN. Hokkaido: in alpibus Tokachi, 1500 m., in lacunis

secus nives, *U. Faurie*, no. 6729, July 1905 (holotype; isotype in A. A.).

Acer pellucidobracteatum was first identified with *A. Tschonoskii* by the writer (l. c.).

Acer argutum Maximowicz in Bull. Acad. Sci. St. Pétersb. XII. 226 (1867); in Mél. Biol. VI. 368 (1867).

Acer palmatum var. *plicatum* Léveillé in Bull. Soc. Bot. France, LIII. 592 (1906). — **Synon. nov.**

JAPAN. Hondo: in alpibus Nikko, *U. Faurie*, no. 2309, May 27, 1898 (holotype of *A. palmatum* var. *plicatum;* photo. in A. A.).

The specimen of *A. palmatum* var. *plicatum* in the Léveillé herbarium which consists of a small branch with pistillate flowers does not bear on the label the name given by Léveillé.

Acer Negundo Linnaeus, Spec. Pl. 1056 (1753). — Rehder in Sargent, Trees & Shrubs, II. 26 (1907).

Acer Fauriei Léveillé in Bull. Soc. Bot. France, LIII. 590 (1906).

JAPAN. Hokkaido: Sapparo, dans le jardin de M. Miyabe, *U. Faurie*, no. 6084 bis, July 1905 (holotype of *A. Fauriei;* photo. in A. A.).

The same species is represented in this herbarium by a specimen of Faurie's no. 6084, collected September 1904 in "Yezo in hortis culta." *Acer Fauriei* was first identified with *A. Negundo* by the writer (l. c.).

SAPINDACEAE

Eurycorymbus Cavaleriei Rehder & Handel-Mazzetti.[1]

Rhus Cavalerici Léveillé in Fedde, Rep. Spec. Nov. x. 474 (1912); Fl. Kouy-Tchéou, 411 (1915).

Eurycorymbus austrosinensis Handel-Mazzetti in Anz. Akad. Wiss. Wien, 1922, p. 104 (Pl. Nov. Sin. Forts. 16, p. 4) (1922).

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 1094, June 23, 1903, "petit arbre; il nourrit des insectes de couleur vermillon" (holotype of *Rhus Cavaleriei;* photo. and fragments in A. A.); inter urbes Kutschou and Liping in fruticetis prope vicum Tsaimou, alt. 600 m., *H. Handel-Mazzetti*, no. 10907, July 21, 1917 (syntype of *Eurycorymbus austrosinensis;* isotype in A. A.).

Rhus Cavaleriei was first identified with *Eurycorymbus austrosinensis* by the writer. The species, though apparently rare, has a wide distribution having been found also in Kwangtung, on the Lungtoushan, 60 km. east of Siudsao by R. Mell (Pl. Mell. no. 17) and in Formosa, on the river Shin-chou, prov. Karenko by E. H. Wilson, (no. 11098) and

[1]This combination is being published almost simultaneously by Handel-Mazzetti in a continuation of his Plantae Mellianae which probably will appear before the present paper is out.

by R. Kanehira (no. 14225), the latter specimen with staminate flowers which apparently have not yet been described. They are small, about 4 mm. across, whitish; sepals 5, ovate to oblong-ovate, 1-1.5 mm. long, denticulate, outside like the pedicels densely appressed-pubescent, less so inside; petals 5, oblong-lanceolate about 2 mm. long, unguiculate, villous-pubescent outside and ciliate; disk shallowly cupuliform, with short rounded lobes; stamens 8, nearly twice as long as petals; filaments glabrous, folded twice in bud; rudimentary ovary minute, pubescent.

SABIACEAE

Sabia gracilis Hemsley in Hooker's Icon. XXIX. t. 2831 (1907).

Sabia Dunnii Léveillé in Fedde, Rep. Spec. Nov. IX. 457 (1911); Fl. Kouy-Tchéou, 379 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie*, no. 21bis, April 4, 1902, "fleurs vertes-jaunes" (holotype of *S. Dunnii;* merotype in A. A.).

Sabia yunnanensis Franchet in Bull. Soc. Bot. France, XXXIII. 465 (1886). — Loesener in Ber. Deutsch. Bot. Ges. XXXII. 543 (1914). — Léveillé, Cat. Pl. Yun-Nan, 250 (1917).

Celastrus Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 264 (1914).

CHINA. Y u n n a n : broussailles de Lou-ké-suin, alt. 3000 m., *E. E. Maire,* Apr. 1911, "arbuste grimpant tout-vert, fl. vertes, lèvre inféri. noire" (syntype of *Celastrus Mairei;* photo. in A. A.); brousse des mont. derrière Tong-tchouan, alt. 2600 m., *E. E. Maire,* May 1911, "arbuste grimpant, feuilles caduques, fl. vertes" (syntype of *C. Mairei;* photo. in A. A.).

Celastrus Mairei was according to Loesener, l. c., first identified with *Sabia yunnanensis* by L. Diels.

Sabia Dielsii Léveillé in Fedde, Rep. Spec. Nov. IX. 456 (1911); Fl. Kouy-Tchéou, 379 (1915).

Sabia puberula Rehder & Wilson in Sargent, Pl. Wilson. II. 197 (1914). — Chung in Mem. Sci. Soc. China, I. 153 (Cat. Trees Shrubs China) (1924). — **Synon. nov.**

CHINA. K w e i c h o u : Pin-fa, grande grotte, *J. Cavalerie,* no. 1008, May 14, 1903, "h. 1 m., fl. vertes-jaunes" (syntype of *S. Dielsii;* photo in A. A.); without locality, *J. Esquirol,* no. 474, June 1905, "arbrisseau" (syntype of *S. Dielsii;* merotype in A. A.). H u p e h : Hsing-shan Hsien and Fang Hsien, *E. H. Wilson,* no. 2534a and b (syntypes of *Sabia puberula* in A. A.).

The species was collected in Kweichou also by Y. Tsiang (no. 4630) in 1930 near Cheng-feng.

Sabia parviflora Wallich in Roxburgh, Fl. Ind., ed. Carey, II. 310 (1824). — Léveillé, Fl. Kouy-Tchéou, 379 (1915).

CHINA. Kweichou: Lo-fou, *J. Cavalerie,* no. 3415, Aug. 1909; route de Mou-you-se à Kouan-lin, *J. Cavalerie,* no. 3919, July 25, 1912, "arbuste, fl. vertes" (photo. in A. A.).

Both specimens cited are enumerated in the Flore de Kouy-Tchéou under *S. parviflora,* but only no. 3415 bears the name *S. parviflora* in Léveillé's handwriting, while no. 3919 is labeled *Celastrus* with an apparently unpublished specific epithet.

Sabia parviflora Wall. var. **nitidissima** Léveillé, Fl. Kouy-Tchéou, 379 (1915).

Celastrus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XIII. 262 (1914).

CHINA. Kweichou: without locality, *J. Esquirol,* Aug. 9, 1905 (holotype of *C. Esquirolii* and *Sabia parviflora* var. *nitidissima;* merotype in A. A.).

The variety differs from the type in the generally larger leaves, 10-12 (-15) cm. long and 2.5-4 cm. broad, ovate-oblong to lanceolate-oblong, lustrous and bright green above, lighter green and less lustrous beneath. It resembles Rock's no. 2202 from Burma, but is more lustrous.

Meliosma Oldhami Miquel in Ann. Mus. Bot. Lugd.-Bat. III. 94 (1867); Prol. Fl. Jap. 258 (1867).

Rhus Bofillii Léveillé in Mem. Acad. Ci. Barcelona, XII. 562 (Cat. Pl. Kiang-Sou, 22) (1916). — **Synon. nov.**

CHINA. Kiangsu: Suo-se, Tcha-Tchan, *d'Argy* (1846-66) (holotype of *Rhus Bofillii;* fragments in A. A.).

The specimen cited above represents typical *M. Oldhamii* not *M. sinensis* Nakai which is probably best considered a glabrous or glabrescent variety of the former.

RHAMNACEAE

Zizyphus mauritiana Lamarck, Encycl. Méth. III. 318 (1789).

Zizyphus jujuba (L.) Lamarck, Encycl. Méth. III. 318 (1789). — Léveillé, Cat. Pl. Yun-Nan, 228 (1917). — Non Miller (1768).

Paliurus Mairei Léveillé in Fedde, Rep. Spec. Nov. XII. 535 (1913); Cat. Pl. Yun-Nan, 227 (1917). — **Synon. nov.**

CHINA. Yunnan: brousse, rives du fleuve Bleu, alt. 400 m., *E. E. Maire,* July 1912 (holotype of *Paliurus Mairei;* photo. in A. A.).

Berchemia Giraldiana Schneider, Ill. Handb. Laubholzk. II. 263,

fig. 182 m-n, 183 k (1909); in Sargent, Pl. Wilson. II. 213 (1914). — Léveillé, Cat. Pl. Yun-Nan, 227 (1917).

Microrhamnus Mairei Léveillé in Bull. Géog. Bot. XXV. 26 (1915); Cat. Pl. Yun-Nan, 227 (1917); pro parte. — **Synon. nov.**

? *Microrhamnus Franchetiana* Léveillé, l. c. (1915); l. c. (1917); Cat. Pl. Seu-Tchouan, 152, pl. 57 (1918), Mscr.; pro parte, quoad ramum fructiferum.

CHINA. Yunnan: brousse des coteaux à Tong-tchouan, alt. 2550 m., *E. E. Maire,* May 1912 "arbuste grimpant, feuilles caduques; rameaux long de 2 à 3 m." (syntype of *Microrhamnus Mairei;* merotype in A. A.); brousse des mont. à Siao-ou-long, alt. 2600 m., *E. E. Maire,* June 1912 "arbuste grimpant à long rameaux" (fruiting branch of holotype of *Microrhamnus Franchetiana;* photo. in A. A.).

Both species of *Microrhamnus* cited above are mixtures; one of the specimens cited under *M. Mairei* apparently belongs here, the other to the following species. The specimen of *M. Franchetiana* consists of a flowering branch and of a leafless fruiting branch, the former represents *Tripterygium hypoglaucum* (Lévl.) Hutch. while the fruiting branch, judging from the shape of the inflorescence belongs here, or possibly to *B. floribunda* Wall.

Berchemia pycnantha C. Schneider in Sargent, Pl. Wilson. II. 215 (1914).

Microrhamnus Mairei Léveillé in Bull. Géog. Bot. XXV. 26 (1915); Cat. Pl. Yun-Nan, 227 (1917); pro parte. — **Synon. nov.**

CHINA. Yunnan: brousse des collines à Kiao-me-ti, alt. 3100 m., *E. E. Maire,* May 1913 "arbuste grimpant, long rameaux de 2 à 3 m., fl. blanches, baies noires" (syntype of *Microrhamnus Mairei;* merotype in A. A.).

Rhamnella Martini (Lévl.) Schneider in Sargent, Pl. Wilson. II. 225 (1914) "Martinii." — Léveillé in Fl. Kouy-Tchéou, 341 (1915); Cat. Pl. Yun-Nan, 227 (1917).

Rhamnus Martini Léveillé in Fedde, Rep. Spec. Nov. X. 473 (1912).

Microrhamnus Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 535 (1913); Fl. Kouy-Tchéou, 341 (1915). — **Synon. nov.**

Rhamnus yunnanensis Heppeler in Arch. Pharm. CCLXVI. (Ber. Deutsch. Pharm. Ges. XXVIII.) 167 (March 1928), nomen; in Notizbl. Bot. Gart. Mus. Berlin, X. 343 (June 1928). — **Synon. nov.**

CHINA. Hupeh: Chanyang, *E. H. Wilson,* Veitch Exp. no. 1990, April 1901 (semiscandent shrub, 20 ft.). Kweichou: environs de Gan-pin, rochers au dessus de Ta-tong, *L. Martin* in hb. *Bodinier,* no. 2299, May 23, 1898 "arbuste, fl. verdâtres" (holotype of

Rhamnus Martini; merotype in A. A.); Tsin-gai, bois, *J. Cavalerie,* no. 1152, July 15, 1903, "petit arbre" (holotype of *Microrhamnus Cavaleriei;* merotype in A. A.); in fruticetis aridis prope oppidum Huang-tsauba, alt. 1400 m., *Handel-Mazzetti,* no. 10289, June 15, 1917. Yunnan: Mengtze mountains alt. 7000 ft., *A. Henry,* no. 10929 (shrub 4-6 ft., fl. green); in rupestribus calcareis in monte Tschang-tschuan, distr. Yunnan-fu, alt. 2200 m., *O. Schoch,* no. 136 "arbuscula" (holotype of *Rhamnus yunnanensis* in Berlin Mus.; photo. and isotype in A. A.).

Rhamnella rubrinervis (Lévl.), comb. nov.

Embelia rubrinervis Léveillé in Fedde, Rep. Spec. Nov. x. 374 (1912); Fl. Kouy-Tchéou, 285 (1914).

Rhamnella hainanensis Merrill in Philipp. Jour. Sci. xxi. 349 (1922). — **Synon. nov.**

CHINA. Kweichou: without locality, *J. Esquirol,* no. 729 (holotype of *Embelia rubrinervis;* photo. in A. A.); hauteurs de Tong-kai, *J. Esquirol,* no. 3028, July 25, 1911, "fl. vertes" (cited in Fl. Kouy-Tchéou; photo. in A. A.). Hainan: Five Finger Mt., Hop-lo-tsum, *F. A. McClure,* no. 8358, Dec. 6, 1921 (holotype of *Rhamnella hainanensis;* isotype in A. A.).

The Kweichou specimens are in flower, while the Hainan specimen is in fruit, but in their vegetative characters the specimens agree exactly except that the dark reddish color of the veins of the under side of the leaves is lacking on the Hainan specimen; it is apparently more prominent on younger leaves. Also the transverse trabecular veinlets are not quite as conspicuous as in the Kweichou specimens. In all specimens the petioles are minutely puberulous, a character not mentioned by Merrill. The floral characters are not different from those of *Rhamnella franguloides* (Maxim.) Weberb. as figured by Maximowicz under *Microrhamnus franguloides* Maxim. (in Mém. Acad. Sci. St. Pétersb. sér. 7, x. no. 11, t. fig. 15-22. 1866) and by Schneider (Ill. Handb. Laubholzk. II. 262, fig. 183 h-l. 1909). The flowers appear in fascicles of 3-7; occasionally two fascicles are borne on short axillary branchlets 5-10 mm. long or sometimes elongated axillary branchlets bear fascicles in the axils of small leaves, resembling in this respect *Rhamnus Esquirolii* Lévl. and *Rh. napalensis* Wall. The petals of *Rh. rubrinervis* are emarginate and the sepals bear on the inside the lamella-like midrib indicated in Schneider's figure, but not shown by Maximowicz.

Sageretia rugosa Hance in Jour. Bot. XVI. 9 (1878). — Schneider in Sargent, Pl. Wilson. II. 227 (1914).

Quercus Dunniana Léveillé in Fedde, Rep. Spec. Nov. XII. 363 (1913). — **Synon. nov.**

China. Kweichou: without locality, *J. Cavalerie* (holotype of *Quercus Dunniana;* photo. in A. A.).

Quercus Dunniana was first identified with *Sageretia rugosa* by W. S. Evans according to a note on the label of the type specimen, but the identification was not published. *Quercus Dunniana* does not appear under *Quercus* in the Flore de Kouy-Tchéou and probably was referred by Léveillé to some other plant.

Sageretia theezans (L.) Brongniart in Ann. Sci. Nat. x. 360 (Mém. Fam. Rhamn. 53) (1826).

Berchemia Chaneti Léveillé in Fedde, Rep. Spec. Nov. x. 433 (1912). — **Synon. nov.**

Sageretia Chanetii Schneider in Sargent, Pl. Wilson. II. 228 (1914).

China. Hopei: montagnes de Ping-chan, *L. Chanet,* no. 232, June 15, 1908 "arbuste épineux" (holotype of *Berchemia Chaneti;* merotype in A. A.).

Berchemia Chaneti was referred to *Sageretia* by C. Schneider and doubtfully enumerated as a new species under *S. theezans.* It does not seem to me specifically distinct from that variable species.

Sageretia Henryi Drummond & Sprague in Kew Bull. Misc. Inform. 1908, p. 14; 1914, p. 175. — Schneider in Sargent, Pl. Wilson. II. 623 (1916).

Berchemia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. x. 433 (1912).

Sageretia Cavaleriei Schneider in Sargent, Pl. Wilson. II. 228 (1914). — Léveillé, Fl. Kouy-Tchéou, 343 (1915).

China. Kweichou: Keou-tchang, Kouy-tin, *J. Cavalerie,* no. 725, Nov. 23, 1902 (holotype of *Berchemia Cavaleriei;* photo. in A. A.).

Rhamnus crenatus Siebold & Zuccarini in Abh. Akad. Muench. IV. pt. II. 146 (Fl. Jap. Fam. Nat. I. 38) (1845). — Schneider in Sargent, Pl. Wilson. II. 232, 244 (1914). — Léveillé, Cat. Pl. Yun-Nan, 228 (1917).

Rhamnus pseudo-frangula Léveillé in Fedde, Rep. Spec. Nov. x. 473 (1912); Fl. Kouy-Tchéou, 343 (1915). — Schneider in Sargent, Pl. Wilson. II. 245 (1914). — **Synon. nov.**

Celastrus Esquirolianus Léveillé in Fl. Kouy-Tchéou, 69 (1914). — **Synon. nov.**

Celastrus Kouytchensis Léveillé in Fedde, Rep. Spec. Nov. XIII. 263 (1914). — **Synon. nov.**

China. Kweichou: environs de Kouy-yang, mont du Collège, le long de l'aqueduc (Ye-mou-kiang-tse), *E. Bodinier,* no. 1620, June 10, 1897 "fleurs jaunes-verdâtres" (holotype of *Rh. pseudo-frangula;* photo. in A. A.); chemin de Tong-tcheou, rochers, alt. 1000

m., *J. Esquirol,* no. 3612 (cited in Fl. Kouy-Tchéou as 3618), June 1912 "frutescent, ne s'élève guère qu'à 2 m., mais ses branches s'étendent" (holotype of *Celastrus Esquirolianus;* photo. in A. A.); Pin-fa, Majo, *J. Cavalerie,* no. 3349 (holotype of *Celastrus Kouytchensis;* photo. in A. A.).

Schneider speaks (l. c.) of *Rh. pseudo-frangula* as a species closely related to *Rh. crenatus* or perhaps a variety and gives a full description of it based on Léveillé's specimen. I cannot see any difference from the variable *Rh. crenatus.*

Rhamnus heterophyllus Oliver in Hooker's Icon. XVIII. t. 1759 (1888). — Schneider in Sargent, Pl. Wilson. II. 232 (1914). — Léveillé, Fl. Kouy-Tchéou, 342 (1915).

Rhamnus Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 326 (1910).

CHINA. Kweichou: près Pin-yue, *J. Cavalerie,* no. 2477, Aug. 1, 1905, "arbuste de 1 m. 50" (holotype of *Rh. Cavaleriei;* photo. in A. A.).

Schneider first identified *Rh. Cavaleriei* with *Rh. heterophyllus* and Léveillé cites in his Flore de Kouy-Tchéou the specimen under *Rh. heterophyllus* without citing a synonym.

Rhamnus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. X. 473 (1912); Fl. Kouy-Tchéou, 342 (1915). — Schneider, in Sargent, Pl. Wilson. II. 233 (1914).

Celastrus? Lyi Léveillé in Fedde, Rep. Spec. Nov. XIII. 264 (1914). — **Synon. nov.**

Sageretia Bodinieri Léveillé, Fl. Kouy-Tchéou, 343 (1915).

CHINA. Kweichou: Pin-fa, sous bois, *J. Esquirol,* no. 392, June 15, 1905 (holotype of *Rh. Esquirolii;* photo. in A. A.); environs de Kouy-yang, mont du Collège, *E. Bodinier,* June 3, 1898 (holotype of *Celastrus Lyi* and *Sageretia Bodinieri;* photo. in A. A.).

Schneider gives (l. c.) a complete description of the species. Léveillé cites in his Flore de Kouy-Tchéou *Celastrus Lyi* as a synonym of the new name *Sageretia Bodinieri* and enumerates besides Bodinier's specimen Esquirol's no. 3771 "route de Tong-tchéou, 1200 m., 1912" which I have not seen.

Rhamnus napalensis (Wall.) M. A. Lawson in Hooker f., Fl. Brit. India, I. 640 (1875), *"nipalensis."*

Ceanothus napalensis Wallich in Roxburgh, Fl. Ind. ed. Carey, II. 375, 575 (1824).

Rhamnus paniculiflorus Schneider in Sargent, Pl. Wilson. II. 233 (March 1914). — **Synon. nov.**

Celastrus tristis Léveillé in Fedde, Rep. Spec. Nov. XIII. 263 (May 1914). — **Synon. nov.**

CHINA. K w e i c h o u : without locality, *J. Esquirol,* (holotype [2 sheets] of *Celastrus tristis,* photos. in A. A.).

I am unable to separate *Rh. paniculiflorus* Schneid. from *Rh. napalensis* M. Laws. The distinguishing characters given by Schneider do not seem to hold; I find verrucose branches in a specimen from Assam (*L. F. Ruse,* no. 58a) and in a specimen from Sumatra (*H. S. Yates,* no. 725); and the branching of the panicle varies so greatly in the 28 specimens before me that no line can be drawn. The species has a very wide distribution; it occurs throughout China except the northern provinces and extends through India and Indochina to Malaysia.

The specific epithet was published originally by Wallich (l. c.) under *Ceanothus* as *"napalansis,"* but this spelling was corrected in the same volume on p. 575 to *"napalensis"* which must be accepted as the correct spelling of the name, though most later authors, following Lawson spelled it *"nipalensis"* or sometimes *"nepalensis."*

Rhamnus Bodinieri Léveillé in Fedde, Rep. Spec. Nov. x. 473 (1912); Fl. Kouy-Tchéou, 342 (1915). — Schneider in Sargent, Pl. Wilson. II. 246 (1914).

CHINA. K w e i c h o u : environs de Tsin-gay, rochers au bord de la rivière à Ché-tiou-tchay, *E. Bodinier,* no. 2657, June 27, 1899 (holotype; merotype in A. A.).

Schneider (l. c.) gives a complete description of the species partly based on additional material collected by Henry in Yunnan (nos. 10814 and 10814a).

Rhamnus Blinii (Lévl.), comb. nov.

Maesa Blinii Léveillé in Fedde, Rep. Spec. Nov. x. 376 (1912); Fl. Kouy-Tchéou, 286 (1914).

CHINA. K w e i c h o u : Ma-jo, *J. Cavalerie,* no. 3103, July 24, 1907 (holotype of *Maesa Blinii;* merotype in A. A.). S z e c h u a n : Kuan-hsien, alt. 3500-4000 ft., *W. P. Fang,* no. 2243, July 15, 1928 (shrub 4 m.).

Maesa Blinii is apparently conspecific with *Rhamnus Sargentianus* Schneid., but differs in several minor characters, so that the latter is probably best considered a variety of the former, the specific epithet "Blinii" having priority. Cavalerie's no. 3103 differs from *Rh. Sargentianus* chiefly in the quite glabrous, chartaceous and sharply serrulate leaves, distinctly reticulate beneath, with fewer, 10-12, pairs of veins, while in typical *Rh. Sargentianus* Schneid. the leaves are pilose at least on the veins beneath, the serration is minute and the 10-18

pairs of veins are connected by conspicuous trabecular veinlets without visible reticulation between. Fang's no. 2243 approaches the typical form, the veins are more numerous, the trabecular veinlets are more prominent and the serration is less conspicuous; it resembles W. Y. Chun's no. 4023 from Hupeh which, however, is pubescent on the veins and partly on the veinlets beneath and the veins are closer.[1]

Rhamnus serpyllifolius Léveillé in Fedde, Rep. Spec. Nov. XII. 282 (1913), *"serpyllifolia"*; Cat. Pl. Yun-Nan, 228 (1917) *"serpillifolius."*

CHINA. Yunnan: rochers arides de Pan-pien-kai, 2550 m., *E. E. Maire,* May 1912 "arbrisseau épineux rampant, appliquées sur les rochers, fl. blanches" (holotype; merotype in A. A.).

Descriptioni adde: frutex glaberrimus, spinosus, ramulis brevibus suboppositis vel alternis; folia breviter petiolata, coriacea, obovata vel obovato-oblonga, 4-10 mm. longa et 2.5-4 mm. lata, apice rotundata vel leviter emarginata, basi cuneata, integra vel apicem versus sparsissime minute et indistincte denticulata, supra nitida, intense viridia, subtus pallidiora, costa et venis indistinctis; flores (deflorati) solitarii, breviter pedicellati pedicello ca. 1 mm. longo, 4-meri, sepalis triangulari-ovatis, acutiusculis, ca. 1 mm. longis.

This is a very distinct species on account of its very small coriaceous entire or nearly entire leaves. The collector notes the flowers as white, but this may be a mistake, for the few flowers on the specimen show neither petals nor stamens. The species seems best placed near *Rh. Rosthornii* Pritz., *Rh. leptacanthus* Schneid. and *Rh. Leveilleanus* Fedde but these have membranous, distinctly denticulate and generally larger leaves. According to Heppeler's disposition of the species (Beitr. Syst. Rhamnus in Arch. der Pharmazie, CCLVI. 152-173. 1928) it should be placed into his series Coriaceae, though he refers *Rh. Rosthornii* and *Rh. Leveilleanus* to the series Parvifoliae.

Rhamnus Taqueti Léveillé in herb. apud Schneider in Sargent, Pl. Wilson. II. 248 (1914).

[1] **Rhamnus Blinii** var. **Sargentianus** (Schneid.), stat. nov.
Rhamnus Sargentianus Schneider in Sargent, Pl. Wilson. II. 235 (1914).

CHINA. Western Szechuan: Wa-shan, *E. H. Wilson,* no. 862, June and Sept. 1908 (holotype); same locality, *E. H. Wilson,* Veitch Exp. no. 3339a, June 1903 (paratype); Mupin, *E. H. Wilson,* no. 862a, June 1908 (paratype); without precise locality, *E. H. Wilson,* Veitch Exp. no. 3339, May 1904 (paratype). Western Hupeh: 6 li from Hsien-tien-tze, alt. 6500 ft., *W. Y. Chun,* no. 4023, Aug. 23, 1922 (tree, 6 m.). Yunnan: Chien-chuan-Mekong divide, lat. 26° 30-36′ N., long. 99° 40′ E., alt. 9-10000 ft., *G. Forrest,* nos. 21482 and 21976, July and Aug. 1922; without precise locality, *G. Forrest,* no. 26784.

The variety has apparently a much wider distribution than the typical form and probably must be considered the phylogenetic type.

Prunus Taqueti Léveillé in Fedde, Rep. Spec. Nov. VII. 197 (1909).

KOREA. Quelpaert: Hallisan, *E. Taquet,* no. 104, Sept. 1907 (syntype of *Prunus Taqueti;* photo. in A. A.); same locality, *U. Faurie,* no. 1870, July 1907 (syntype of *Prunus Taqueti;* isotype in A. A.).

Prunus Taqueti was first recognized by E. Koehne as a species of *Rhamnus* according to a note on the sheet of Taquet's no. 104 and a reference in Sargent, Pl. Wilson. II. 276 (1912).

Rhamnus Leveilleanus Fedde, Rep. Spec. Nov. X. 272 (1911). — Schneider in Sargent, Pl. Wilson. II. 248 (1914). — Léveillé, Fl. Kouy-Tchéou, 243 (1915).

Rhamnus Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. X. 148 (1911); nec Léveillé, op. cit. IX. 226 (1910).

CHINA. Kweichou: Lo-fou, *J. Cavalerie,* no. 3348, April 1907 (holotype of *Rh. Cavaleriei;* merotype in A. A.); environs de Kouy-yang, *E. Bodinier,* no. 2656, June 15, 1898 (cited in Fl. Kouy-Tchéou; dupl. in A. A.).

Rhamnus leptophyllus Schneider in Notizbl. Bot. Gard. Berlin, v. 77 (1908); in Sargent, Pl. Wilson. II. 239 (1914). — Léveillé, Cat. Pl. Yun-Nan, 228 (1917).

Rhamnus pruniformis Léveillé in Fedde, Rep. Spec. Nov. XII. 534 (1913); Cat. Pl. Yun-Nan, 228 (1917). — **Synon. nov.**

CHINA. Yunnan: Kin-tchong-chan, 2550 m., *E. E. Maire,* April 1912, "arbuste épineux buissonant, haut 1.50 m., fl. jaunes, abondantes" (holotype of *Rh. pruniformis;* merotype in A. A.).

In the Herbarium Léveillé there is another specimen (merotype in A. A.) from the same locality with very young leaves which seems to be referable to *Rh. Rosthornii* Pritz.

Rhamnus Schneideri Léveillé & Vaniot in Fedde, Rep. Spec. Nov. VI. 265 (1908). — Schneider in Sargent, Pl. Wilson. II. 250 (1914).

KOREA: Nai-piang, *U. Faurie,* no. 234, July 1901 (holotype; photo. in A. A.).

Rhamnus hamatidens Léveillé in Fedde, Rep. Spec. Nov. X. 473 (1912); Fl. Kouy-Tchéou, 342 (1915). — Schneider in Sargent, Pl. Wilson. II. 252 (1914).

CHINA. Kweichou: Pin-fa, *J. Cavalerie,* no. 992, April 15, 1903, "arbuste, fl. vertes" (holotype; photo. in A. A.).

Hovenia dulcis Thunberg, Fl. Jap. 101 (1784). — Léveillé, Fl. Kouy-Tchéou, 340 (1915); Cat. Pl. Yun-Nan, 227 (1917).

Zizyphus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. X. 148 (1911); Fl. Kouy-Tchéou, 343 (1915). — **Synon. nov.**

CHINA. Kweichou: without locality, *J. Esquirol,* no. 861

(holotype of *Zizyphus Esquirolii;* merotype in A. A.).

Gouania javanica Miquel, Fl. Ind. Bat. I. pt. 1, p. 649 (1855). — Léveillé, Cat. Pl. Yun-Nan, 227 (1917). — Exell in Sunyatsenia, I. 93 (1933).

Terminalia Kouytchensis Léveillé Cat. Pl. Yun-Nan, 35 (1915), sub *T. Mairei.*

CHINA. Kweichou: Lo-fou, *J. Cavalerie,* no. 3457 (holotype of *Terminalia Kouytchensis;* merotype in A. A.).

Terminalia Kouytchensis was only incidentally mentioned by Léveillé in the description of his *Terminalia Mairei* (l. c.): "folia . . . basi brevissime attenuata nec cordata (ex quo a *T. Kouytchensis* Lévl. diagnoscitur)". *Terminalia Mairei* is according to Exell (l. c. 87) identical with *Combretum Wallichii* DC. *Terminalia Kouytchensis* is not enumerated by Léveillé in his Flore de Kouy-Tchéou; though *Terminalia* appears in the key of genera under Combretaceae (p. 74), no species is listed. Exell (l. c.) first published it as a synonym of *Gouania javanica* Miq., to which I had it already referred in this herbarium.

VITACEAE

Vitis flexuosa Thbg. var. **parvifolia** (Roxb.) Gagnepain in Sargent, Pl. Wilson. I. 103 (1911). — Léveillé, Cat. Pl. Yun-Nan, 8, (1915).

Vitis Cavalerici Léveillé & Vaniot in Bull. Soc. Agr. Sci. Arts Sarthe, XL.[1] 36 (1905); in Fedde, Rep. Spec. Nov. II. 158 (1906).

Vitis flexuosa Léveillé, Fl. Kouy-Tchéou, 27 (1914), pro parte, vix Thunb.

CHINA. Kweichou: Kouy-yang, mont du Collège, *J. Cavalerie,* April 25, 1898 (holotype of *Vitis Cavaleriei;* photo. in A. A.).

Vitis Cavaleriei was referred by Léveillé in his Flore de Kouy-Tchéou to *Vitis flexuosa* as a synonym together with *Vitis Marchandii* Lévl. which, however, belongs to the following species.

Vitis Wilsonae Veitch apud Gard. Chron. ser. 3, XLVI. 236. fig. 101 (1909). — Rehder in Sargent, Pl. Wilson. III. 428 (1917), pro syn. *V. reticulatae* Gagnep.; in Jour. Arnold Arb. XIII. 339 (1932).

Vitis reticulata Pampanini in Nuov. Giorn. Bot. Ital. XVII. 429, fig. 13 (1910); non M. A. Lawson.

Vitis Marchandii Léveillé in Fedde, Rep. Spec. Nov. XII. 531 (1913). — **Synon. nov.**

Vitis flexuosa Léveillé, Fl. Kouy-Tchéou, 27 (1914), quoad syn. *V. Marchandii;* non Thunb.

[1]In the reprint of Léveillé's Les vignes de la Chine, on the cover of the first fascicle containing the original article and in Fedde's Repertorium the volume number is given as LX. instead of XL.

China. Kweichou: Chouang-chan-po, *J. Esquirol,* no. 3143, May 1911 (syntype of *V. Marchandii;* photo. in A. A.); bois, Ganchouen, *J. Cavalerie,* no. 3874 (syntype of *V. Marchandii;* photo. in A. A.).

Vitis Marchandii was reduced by Léveillé in his Flore de Kouy-Tchéou to a synonym of *V. flexuosa,* but it clearly is identical with *V. Wilsonae* Veitch.

There may be some doubt whether *V. Marchandii,* though later than *V. Wilsonae,* should not be considered the correct name for this species, as it was correctly published with a Latin description and based on type specimens, while the name *V. Wilsonae* was only incidentally mentioned, though with a figure of a leaf. As far as the two descriptions go, they are both unsatisfactory and incomplete, and particularly misleading is Léveillé's statement "*V. inconstanti* Miq. affinis," while *V. Wilsonae* is much more correctly referred as belonging into the affinity of *V. armata.*

Vitis Davidi (Rom. du Caill.) Foëx, Cours Vitic. 44 (1886).

Vitis prunisapida Léveillé & Vaniot in Fedde, Rep. Spec. Nov. III. 350 (1907); Fl. Kouy-Tchéou, 28 (1914). — **Synon. nov.**

China. Kweichou: Touan-po, *J. Cavalerie,* no. 2488, Aug. 13, 1905, "vigne à gros raisins, peu aqueux et à gout de pruneau" (holotype of *V. prunisapida;* photo. in A. A.).

Vitis Thunbergii Sieb. & Zucc. var. **adstricta** (Hance) Gagnepain in Sargent, Pl. Wilson. II. 105 (1911). — Léveillé, Cat. Pl. Yun-Nan, 8 (1915).

Vitis flexuosa Thunb. var. *Mairei* Léveillé in Fedde, Rep. Spec. Nov. VII. 340 (1909); Cat. Pl. Yun-Nan, 8 (1915). — **Synon. nov.**

China. Yunnan: montagnes, *E. E. Maire,* no. 415, May 1906, (holotype of *V. flexuosa* var. *Mairei* in herb. Bonati, photo. in A. A.; merotype in herb. Léveillé).

Léveillé in his Catalogue des plantes du Yun-Nan gives for *V. flexuosa* var. *Mairei* the author citation "Lévl. pr. sp. in Fedde, Rep. VII. 338, but this is apparently a mistake; *Vitis Mairei* on that page is partly *Cayratia oligocarpa* var. *glabra* Gagnep. and partly *Tetrastigma serrulatum* (Roxb.) Planch., while the variety appears on p. 340. The actual type of the variety seems to be the specimen in the Herb. Bonati, now in the herbarium of the University of California; the specimen in the Léveillé herbarium is only a fragment.

Tetrastigma Hemsleyanum Diels & Gilg in Bot. Jahrb. XXIX. 463 (1900). — Gagnepain in Lecomte, Not. Syst. I. 317 (1911).

Vitis Labordei Léveillé in Bull. Soc. Agric. Sci. Arts. Sarthe, XL. 40

(1905); in Fedde, Rep. Spec. Nov. II. 158 (1906); Fl. Kouy-Tchéou, *27* (1914). — **Synon. nov.**

Vitis Esquirolii Léveillé & Vaniot in Fedde, Rep. Spec. Nov. III. 20 (1906); Fl. Kouy-Tchéou, *27* (1914); Cat. Pl. Yun-Nan, 8 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Kouang-chouen, bois de Ma-yan-chan, *J. Laborde*, no. 2695, Aug. 27, 1899 (holotype of *Vitis Labordei;* photo. in A. A.); Pin-fa, *J. Cavalerie*, no. 1051, June 11, 1903 "fl. blanches" (holotype of *Vitis Esquirolii;* merotype in A. A.).

It is not without hesitation that I refer *Vitis Labordei* as a synonym to *T. Hemsleyanum*, but I cannot see the slightest difference in the leaves of both species; also the inflorescence seems to be the same, though the type of *T. Hemsleyanum* is in flower, while that of *Vitis Labordei* is in fruit and has the secondary axes longer. Gagnepain (l. c.) describes the fruit of *T. Hemsleyanum* from a specimen collected by Farges in eastern Szechuan as being globose with two furrowed-ruminate seeds, while the fruit of *V. Labordei* is pyriform with one seed which has two deep furrows on the ventral side, but the shape of the fruit would change with the number of seeds which is variable in most species.

In the Flore de Kouy-Tchéou Léveillé enumerated under *Vitis Esquirolii* another specimen, *J. Cavalerie*, no. 2471, July 26, 1905, which according to a duplicate before me belongs to *Cayratia oligocarpa* (Lévl. & Vant.) var. *glabra* Gagnep.

Tetrastigma serrulatum (Roxb.) Planchon in de Candolle, Monog. Phaner. v. 432 (1887). — Gagnepain in Lecomte, Not. Syst. I. 322 (1911).

Vitis Mairei Léveillé in Fedde, Rep. Spec. Nov. VII. 338 (1909), pro parte, quoad no. 412. — **Synon. nov.**

Vitis flexuosa Thbg. var. *Mairei* pr. sp. Léveillé, Cat. Pl. Yun-Nan, 8 (1915), errore.

CHINA. Y u n n a n : fôrets des montagnes, *E. E. Maire*, no. 412, May 1904 "tiges perissantes tous les ans" (syntype of *Vitis Mairei* in hb. Bonati; photo. in A. A.).

Léveillé cites under *V. Mairei* two numbers 412 and 414 which I have seen in the herbarium Bonati, now in the herbarium of the University of California, with the name *Vitis Mairei* sp. nov. in Léveillé's handwriting. Whether there are duplicates in the Léveillé herbarium I do not know. Maire's no. 414 is *Cayratia oligocarpa* (Lévl.) var. *glabra* Gagnep.

In his Catalogue des plantes de Yun-Nan Léveillé cites under *Vitis flexuosa* var. *Mairei* Lévl. pr. sp. the reference to *V. Mairei*, apparently

confusing it with the plant described under the former name on page 340, which is identical with *Vitis Thunbergii* S. & Z. var. *adstricta* (Hance) Gagnep.

In 1912 Léveillé used the name *V. Mairei* a second time for an entirely different plant belonging to the Cucurbitaceae (see p. 27).

Tetrastigma obtectum (Wall.) Planch. var. *β* **glabrum** Gagnepain in Lecomte, Not. Syst. I. 323 (1911).

Vitis umbellata Hemsley in Jour. Linn. Soc. Bot. XXV. 137 (1886). — Léveillé in Bull. Agric. Sci. Arts Sarthe, XL. 45 (1905).

Vitis Potentilla Lévl. & Vant. var. *glabra* Léveillé in Bull. Agr. Sci. Sarthe, XL. 43 (1905); in Fedde, Rep. Spec. Nov. II. 160 (1906).

Vitis obtecta Wall. var. *Potentilla* f. *glabra* (Lévl.) Léveillé, Fl. Kouy-Tchéou, 28 (1914).

Vitis obtecta Wall. var. *glabra* (Lévl.) Léveillé, Cat. Pl. Yun-Nan, 8 (1915).

CHINA. Kweichou: environs de Gan-pin, sur les rochers, aux Grandes Rocailles, *L. Martin & E. Bodinier,* no. 1879, p. p., Sept. 26, 1897 (syntype of *Vitis Potentilla* var. *glabra,* ex Léveillé); environs de Gan-pin, rochers à la depression, grotte; environs de Ou-la-gay, sur les rochers, *L. Martin & E. Bodinier,* nos. 2191, 2191bis, p. p., (syntype of *V. Potentilla* var. *glabra,* p. p.; photo. in A. A.); Pin-fa, *J. Cavalerie,* nos. 1331, 1332, 3253, May & July 1902 and May 1908 (cited under *V. obtecta* var. *Potentilla* f. *glabra* in Fl. Kouy-Tchéou; photos. in A. A.).

In his original publication of *Vitis Potentilla* and var. *glabra,* Léveillé cites the types in one paragraph at the end without indicating which specimens represent the type of the species and which that of the variety, but the fact that both type numbers 1879 and 2191 consist each of both forms, may be his reason for not separating them in his citations. Of no. 1879 I have seen only var. *pilosa,* and no. 2191 he separates in Flore de Kouy-tchéou into no. 2191 and no. 2191bis.

Vitis umbellata Hemsl. = *Tetrastigma umbellatum* (Hemsl.) Nakai, of which I have seen the type in Kew, does not seem to be different from *T. obtectum* var. *glabrum;* Nakai refers also *Vitis arisanensis* Hay. as a synonym to *T. umbellatum* (in Tokyo Bot. Mag. XXXVI, 69. 1922). Léveillé (l. c.) cites in 1905 Cavalerie nos. 1331 and 1332 under *Vitis umbellata* Hemsl., but in his Flore de Kouy-Tchéou he enumerates them under *V. obtecta* var. *Potentilla* f. *glabra.* Gagnepain in his Essai de classification du genre *Tetrastigma* (in Lecomte, Not. Syst. I. 306-326. 1911) does not mention *Vitis umbellata* Hemsl. at all.

Tetrastigma obtectum var. **Potentilla** (Lévl. & Vant.) Gagnepain in Lecomte, Not. Syst. I. 323 (1911).

Vitis Potentilla Léveillé & Vaniot in Bull. Agric. Sci. Arts Sarthe, XL. 43 (1905); in Fedde, Rep. Spec. Nov. II. 159 (1906).

Vitis obtecta var. *Potentilla* f. *pilosa* (Pl.) Léveillé, Fl. Kouy-Tchéou, 28 (1914); vix *T. obtectum* var. *pilosum* Pl. apud Gagnep.

Vitis obtecta Wall. var. *Potentilla* (Lévl. & Vant.) Léveillé, Cat. Pl. Yun-Nan, 9 (1915).

CHINA. K w e i c h o u : environs de Gan-pin, sur les rochers, aux Grandes Rocailles, *L. Martin & E. Bodinier,* no. 1879, p. p., Sept. 26, 1897 (syntype of *Vitis Potentilla;* photo. in A. A.); environs de Gan-pin, rochers à la depression, grotte; environs de Ou-la-gay, sur les rochers, *L. Martin* in herb. *E. Bodinier,* no. 2191bis (syntype of *V. Potentilla;* photo. in A. A.).

In his Flore de Kouy-Tchéou Léveillé places *Vitis Potentilla* under *V. obtecta* var. *Potentilla* f. *pilosa,* but in his Cat. Pl. Yun-Nan he separates var. *pilosa* and var. *Potentilla* following Gagnepain.

Parthenocissus himalayana (Royle) Planch. var. **rubrifolia** (Lévl. & Vant.) Gagnepain in Sargent, Pl. Wilson. I. 101 (1911).

Vitis rubrifolia Léveillé & Vaniot in Bull. Soc. Agric. Sci. Sarthe XL. 44 (1905); in Fedde, Rep. Spec. Nov. II. 101 (1911).

Vitis Delavayana Léveillé, Fl. Kouy-Tchéou, 27 (1914), tandem quoad synon. *V. rubrifolia;* non *V. Delavayana* (Planch.) Franch.

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège, gorges de Yang-pa, *E. Bodinier,* no. 2457, p. p., July 20, 1898 "liane ligneuse, pedoncules rouges" (syntype of *Vitis rubrifolia;* photo. in A. A.); mont de Kao-po, sur les rochers, *E. Bodinier,* no. 2457, p. p., Nov. 8, 1899, "pedoncules et feuilles rouges" (syntype of *Vitis rubrifolia;* photo. in A. A.).

Vitis rubrifolia was referred in 1911 by Gagnepain as a variety to *Parthenocissus himalayana,* but in 1914 Léveillé made it a synonym of *V. Delavayana.* Whether Cavalerie's specimen from Pin-fa, also cited under *V. Delavayana* belongs to that species or to *P. himalayana* var. *rubrifolia* I do not know.

Parthenocissus heterophylla (Bl.) Merrill in Philipp. Jour. Sci. XIII. Bot. 143 (1918).

Vitis Feddei Léveillé in Fedde, Rep. Spec. Nov. VII. 231 (1909). — **Synon. nov.**

CHINA. K w e i c h o u : route de Pin-fa à Tou-yun, *J. Cavalerie,* no. 3347, Aug. 2, 1908 (holotype of *Vitis Feddei;* merotype in A. A.).

Vitis Feddei is not mentioned by Léveillé in his Flore de Kouy-Tchéou nor do I find Cavalerie's number cited under any other species of *Vitis.*

Parthenocissus tricuspidata (Sieb. & Zucc.) Planchon in De Candolle, Monog. Phaner. v. 452 (1887).

Vitis Taquetii Léveillé in Bull. Acad. Intern. Géog. Bot. xx. 11 (1910). — **Synon. nov.**

Psedera Thunbergii (Sieb. & Zucc.) Nakai, Fl. Sylv. Kor. xii. 11, pl. 1 (1922).

Korea. Quelpaert: scandens in muris agrorum Hongno, *E. Taquet,* no. 648, July 1908 (holotype of *V. Taquetii;* isotype in A. A.).

Vitis Taqueti was first identified with *P. tricuspidata* by Nakai (l. c.); it represents the juvenile form of *Parthenocissus tricuspidata;* Taquet's no. 648 is sterile, but his no. 5454 also under *V. Taquetii* in the Herb. Léveillé collected August 1911 at the same locality bears small inflorescences. Of the three other specimens before me collected by Faurie July 1908 at the same locality, no. 646 is similar to the type of *V. Taquetii,* no. 647 bears the large three-lobed leaves characteristic for the mature plant, and no. 649 is intermediate; all three have inflorescences with flower-buds.

Ampelopsis Bodinieri (Lévl. & Vant.), comb. nov.

Vitis Bodinieri Léveillé & Vaniot in Bull. Soc. Agric. Sci. Sarthe, xl. 36 (1915); in Fedde, Rep. Spec. Nov. ii. 157 (1906).

Vitis heterophylla Léveillé, Fl. Kouy-Tchéou, *27* (1914), p. p.; vix Thunberg.

Ampelopsis micans Rehder in Mitteil. Deutsch. Dendr. Ges. xxi. 188 (1912). — **Synon. nov.**

China. Kweichou: environs de Kouy-yang, mont du Collège, haies, rochers, *E. Bodinier,* no. 2291, May 29 and June 16, 1898 "liane ligneuse à long sarments" (syntypes of *Vitis Bodinieri;* photo. of specimen of May 29 in A. A.).

Vitis Bodinieri is referred by Léveillé in his Flore de Kouy-Tchéou as a synonym to *V. heterophylla* Thunb. (= *Ampelopsis brevipedunculata* [Maxim.] Koehne), but it apparently is identical with the closely related *A. micans* Rehd., a name over which the specific epithet of *V. Bodinieri* has priority.

Ampelopsis Bodinieri var. **cinerea** (Gagnep.), comb. nov.

Vitis Lyjoannis Léveillé in Bull. Bot. Soc. France, liv. 369 (1907).

Ampelopsis heterophylla var. *cinerea* Gagnepain in Sargent, Pl. Wilson. i. 101 (1911), p. p.

Ampelopsis micans var. *cinerea* Rehder in Mitt. Deutsch. Dendr. Ges. xxi. 189 (1912).

Vitis heterophylla Léveillé, Fl. Kouy-Tchéou, 27 (1914), p. p.; non Thunberg.

China. Kweichou: Pin-uo, Ton-yun, terrains pierreux, *J.*

Cavalerie, no. 2478, Aug. 1, 1905 "plante de 2 à 4 metres, assez dressée" (holotype of *Vitis Lyjoannis;* photo. in A. A.).

Vitis Lyjoannis was referred as a synonym to *V. heterophylla* by Léveillé (l. c.), but apparently belongs to *A. micans* var. *cinerea*, though it differs from the type of that variety by the slightly or scarcely 3-lobed leaves, but the branch and the leaves beneath are rather densely pubescent.

Ampelopsis Delavayana Planchon in De Candolle, Monogr. Phaner. v. 458 (1887).

Vitis rigida Léveillé & Vaniot in Bull. Agric. Sci. Sarthe XL. 44 (1905); in Fedde, Rep. Spec. Nov. II. 160 (1906); Fl. Kouy-Tchéou, 28 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège, *E. Bodinier*, no. 2402 p. p., May 28, 1898 (syntype of *Vitis rigida;* photo. and merotype in A. A.); haies près de Kien-lin-chan, *E. Bodinier*, no. 2402, p. p., July 7, 1898 (syntype of *V. rigida*, ex Léveillé).

Ampelopsis Delavayana var. **Gentiliana** (Lévl. & Vant.), comb. nov.

Vitis Gentiliana Léveillé & Vaniot in Bull. Agric. Soc. Sarthe, XL. 38 (1905); in Fedde, Rep. Spec. Nov. II. 158 (1906); Fl. Kouy-Tchéou, 27 (1914).

Ampelopsis heterophylla var. *Gentiliana* (Lévl. & Vant.) Gagnepain in Sargent, Pl. Wilson. I. 100 (1911).

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège (N.-D. de Liesse), haies, *E. Bodinier*, no. 2301, June 9, 1898, "grande liane sous-ligneuse" (holotype of *Vitis Gentiliana*, merotype in A. A.).

Vitis Gentiliana was referred by Gagnepain (l. c.) as a variety to *A. heterophylla* S. & Z. = *A. brevipedunculata* (Maxim.) Koehne, as was also *A. Delavayana*, but they are hardly conspecific with *A. brevipedunculata* which always has undivided though more or less lobed leaves and fruits of a different color. *Vitis Gentiliana* and *A. Delavayana* though quite distinct in their extreme forms are apparently variations of a polymorphous species, since their typical forms are connected by intermediate specimens, as Wilson, no. 604, from Hupeh, Bock & Rosthorn, no. 1540[1] and Fang, no. 473, from Szechuan, Schoch, no. 168, and Rock, no. 6389, from Yunnan. Both forms vary from densely pilose on the veins to quite glabrous. In the shape of the foliage Wilson, no. 2734, is very similar to the type of *Vitis Gentiliana*,

[1]See Jour. Arnold Arb. XIV. 349 (1923).

but the leaves are quite glabrous, while in the latter the veins beneath are densely pilose.

Ampelopsis aconitifolia Bge. var. **palmiloba** (Carr.) Rehder in Mitt. Deutsch. Dendr. Ges. XXI. 190 (1912); in Sargent, Pl. Wilson, III. 427 (1917).

Vitis Dunniana Léveillé in Fedde, Rep. Spec. Nov. XI. 297 (1912). — **Synon. nov.**

KOREA: in dumosis Chinnampo, *U. Faurie,* no. 535, Aug. 1906 (holotype of *Vitis Dunniana;* merotype in A. A.).

There are no specimens either of *A. aconitifolia* or of this variety from Korea in this herbarium, nor can I find any records. Faurie's no. 535 is not represented in this herbarium, though we have a good set of his collections.

Ampelopsis Chaffanjoni (Lévl.), comb. nov.

Vitis Chaffanjoni Léveillé in Bull. Soc. Agric. Sci. Sarthe XL. 37 (1905).

Leea Dielsii Léveillé in Fedde, Rep. Spec. Nov. VIII. 58 (1910); Fl. Kouy-Tchéou, 25 (1914). — **Synon. nov.**

Meliosma? Cavalerici Léveillé in Fedde, Rep. Spec. Nov. IX. 457 (1911); Fl. Kouy-Tchéou, 378 (1915). — **Synon. nov.**

Vitis megaphylla Léveillé, Fl. Kouy-Tchéou, 28 (1914); nom. nudum. — **Synon. nov.**

Ampelopsis Watsoniana Wilson in Jour. Roy. Hort. Soc. XLII. 37 (1916), nom. nud. — Rehder & Wilson in Sargent, Pl. Wilson. III. 427 (1917). — **Synon. nov.**

CHINA. Kweichou: environs de Kouy-yang, mont du Collège, gorges de Yang-pa, *J. Chaffanjon* in herb. *Bodinier,* no. 2386, June 20, 1898 "grande liane sous-ligneuse" (holotype of *Vitis Chaffanjoni;* photo. in A. A.); Tsin-gay, *J. Cavalerie,* no. 1243, Aug. 1903 (holotype of *Leea Dielsii;* photo. in A. A.); Pin-fa, *J. Cavalerie,* no. 1027, June 3, 1903 "fl. vert-jaunes" (holotype of *Meliosma Cavaleriei;* photo. in A. A.); Pin-fa, Kiang-ouang, *J. Cavalerie,* no. 2362, May 25, 1905 (holotype of *Vitis megaphylla;* photo. in A. A.).

The type specimen of *Vitis Chaffanjoni* is enumerated by Léveillé in his Flore de Kouy-Tchéou under *Leea Dielsii* without *V. Chaffanjoni* being cited as a synonym. *Vitis megaphylla* Lévl. is published by Léveillé (l. c.) without description and I was unable to find any previous reference to it. From a pencil note apparently not in Léveillé's handwriting on the type specimen reading "Vitis aff. *V. megaphylla*" I assume that this name is probably a slip of the pen for *V. megalophylla,* and Léveillé took it up by mistake as *V. megaphylla* Lévl. when compiling his Flore de Kouy-Tchéou. The only complete leaf of the type

specimen is from a vigorous shoot and has coarsely serrate unusually large leaflets (up to 11 cm. long).

Ampelopsis cantoniensis (Hook. & Arn.) Planchon in De Candolle, Monog. Phaner. v. 460 (1887).

Vitis multijugata Léveillé & Vaniot in Bull. Soc. Agric. Sci. Sarthe XL. 41 (1905); in Fedde, Rep. Spec. Nov. II. 159 (1906); Fl. Kouy-Tchéou, 28 (1914). — **Synon. nov.**

Leea theifera Léveillé in Fedde, Rep. Spec. Nov. VIII. 58 (1910); Fl. Kouy-Tchéou, 25 (1914). — **Synon. nov.**

CHINA. Kweichou: environs de Tou-chan, *J. Cavalerie,* June-July 1899 (holotype of *Vitis multijugata;* photo. in A. A.); Pin-fa, cataracte au sud-ouest, fourrés, *J. Cavalerie,* no. 243, Aug. 21, 1902, "les Miao-tsè font leur thé avec le fruit mûr violet de cette plante" (holotype of *Leea theifera;* photo. in A. A.).

The two specimens cited above differ considerably in the shape of their leaflets; in the specimen from Tou-chan they are generally ovate and shallowly toothed, while in that from Pin-fa they are oblong-ovate to oblong-lanceolate and coarsely toothed. The latter is apparently referable to var. *grosse-dentata* Hand.-Mazz. (in Anz. Akad. Wiss. Wien, 1922, p. 105 [Pl. Nov. Sin. Forts. 16, p. 43]), which is closely connected with the type by intermediate forms.

Cayratia oligocarpa (Lévl. & Vant.) Gagnepain in Lecomte, Not. Syst. I. 348, 359 (1911).

Vitis oligocarpa Léveillé & Vaniot in Bull. Soc. Agric. Sci. Sarthe, XL. 41 (1905); in Fedde, Rep. Spec. Nov. II. 159 (1906); Fl. Kouy-Tchéou, 28 (1914); Cat. Pl. Yun-Nan, 8 (1915).

Columella oligocarpa (Lévl.) Rehder in Jour. Arnold Arb. II. 177 (1921).

CHINA. Kweichou: environs de Kouy-Yang, C. dans les haies, *E. Bodinier,* no. 2387, June 29, 1908 (holotype of *Vitis oligocarpa* (2 sheets, flowers and fruits); 2 photos. in A. A.).

I have taken up again the generic name *Cayratia* Juss., since *Columellia* Ruiz & Pav. will be proposed and doubtless accepted as a nomen conservandum to prevent the renaming, on account of the priority of *Columella* Lour., of *Columellia* which represents a distinct family. Both names must be regarded as orthographic variants, having been given in honor of the same man.

Cayratia oligocarpa var. **glabra** Gagnepain in Lecomte, Not. Syst. I. 360 (1911).

Vitis Mairei Léveillé in Fedde Rep. Spec. Nov. VII. 338 (1909), quoad Maire, no. 414. — **Synon. nov.**

CHINA. Yunnan: forêts des montagnes, *E. E. Maire,* no. 414,

May 1904 (syntype of *V. Mairei* [in herb. Bonati]; photo. in A. A.).

As in the case of Maire, no. 412 (see under *Tetrastigma serrulatum*), I have seen a specimen of Maire, no. 414, only in the herbarium Bonati. This is apparently the actual type specimen and has the name, *Vitis Mairei* sp. nov., in Léveillé's handwriting.

Cayratia dichromocarpa (Lévl.), comb. nov.

Vitis dichromocarpa Léveillé in Fedde, Rep. Spec. Nov. III. 350 (1907); Fl. Kouy-Tchéou, 27 (1914).

China. Kweichou: Pin-fa, *J. Cavalerie*, no. 2416, July 19, 1905, "fruit jaune avant complète maturité, devient ensuite noir luisant" (holotype of *Vitis dichromocarpa;* merotype in A. A.).

I have not been able to identify this plant with any described species; it looks quite distinct on account of its large leaflets rather densely covered beneath with gray villous pubescence, the veins being densely pilose; the middle leaflet is oblong, acuminate, about 11 cm. long and 4.5 cm. wide, the lateral ones oval or ovate, about 7 cm. long and 4 cm. wide, acute or obtuse and mucronate, coarsely crenate-dentate. It is perhaps nearest to *C. oligocarpa,* but the peduncle is articulate and bracteoled in the middle; the seeds are similar to those of that species and prominently T-shaped in cross-section.

Three of the new species of *Vitis* proposed by Léveillé do not belong to the Vitaceae but to the Cucurbitaceae. These are: *Vitis Martini* Léveillé & Vaniot (in Bull. Soc. Agric. Sci. Sarthe, XL. 41. 1905), *Vitis quelpaertensis* Léveillé (in Fedde, Rep. Spec. Nov. X. 351. 1912)[1] and *Vitis Mairei* Léveillé (in op. cit. XI. 299. 1912; not Léveillé 1909) which apparently all belong to the widely distributed and variable *Gynostemma pentaphyllum* (Thunb.) Makino (*G. pedatum* Bl.).

(*To be continued*)

Herbarium, Arnold Arboretum,
Harvard University.

[1]The holotype of *Vitis quelpaertensis* is Taquet no. 2745, as cited by Léveillé, but in his herbarium this specimen bears only the name *V. Taquetii* in Léveillé's handwriting, a name given by him the year before to *Parthenocissus tricuspidata.*

SPECIATION IN UVULARIA

EDGAR ANDERSON AND THOMAS W. WHITAKER

With plates 82 and 83 and five text figures

I. A CYTOLOGICAL SURVEY OF UVULARIA

THE PURPOSE of this section of the investigation was to determine by cytological examination the evolutionary importance of certain phenomena already known to occur in the genus *Uvularia*. Belling (1925) had shown that in *U. grandiflora* non-disjunction, lack of pairing, fragmentation of chromosomes, and the duplication of single chromosomes or the entire chromosome complement may take place under experimental conditions. Our problem was to determine whether in the genus *Uvularia* these phenomena are of importance in the differentiation of species. If chromosome duplication has been one of the causes of specific differentiation, these two species of *Uvularia* should differ in their chromosome number. If the entire chromosome set has been duplicated, one would expect to find polyploid strains within the species, such as have been reported for *Tradescantia* (Anderson and Diehl 1932), *Tripsacum* (Mangelsdorf and Reeves, 1931) and other genera. If chromosome fragmentation has been involved in species differentiation, one would expect to find single individuals or whole geographic races characterized by the possession of fragmented chromosomes.

The material is excellent for such a study. The species under consideration have well-marked specific differences and the chromosome complement of one species has been worked out in detail (Belling, 1925). It has seven (n) chromosomes, each of which can be identified by its morphological peculiarities. Therefore if gross chromosomal differences are responsible for specific differentiation in this genus, the point should be rather easily detected.

An effort was made to obtain plants for cytological examination from as many widely separated points as possible. *Uvularia grandiflora* was collected at five points and *U. perfoliata* at two. The data are summarized in Table I.

TABLE I.

Species	Locality	No. of Plants Examined	Chromosome Number (n)
U. grandiflora	Herculaneum, Mo.	2	7
	Cliff Cave, Mo.	3	7
	Farmington, Ark.	3	7
	Schoolcraft, Mich.	1	7
	Hamilton, N. Y.	1	7 + f
U. perfoliata	Great Smoky Mts., N. C.	2	7
	New Canton, Virginia	3	7

As shown in Figure 1 there are no evident differences in chromosome size or configuration between the species, and there is only one case of an intra-specific difference, the plant examined at Hamilton, N. Y. For this observation we are indebted to Dr. C. L. Stebbins, who kindly made a cytological examination of local material. He found the characteristic chromosome complement for the genus, and in part of the microspores an additional fragment chromosome, much smaller than the others and similar to those reported by Belling (1925). Fragmentation, therefore, can and does take place in nature as well as in the laboratory, though there is no evidence that it has been of any importance in the differentiating of species within the genus *Uvularia*.

FIGURE 1. Chromosome complements of *Uvularia grandiflora* ('G'), *U. perfoliata* ('P'), and *Oakesia sessilifolia* ('S'), redrawn diagrammatically from the original camera lucida sketches.

The investigation was extended by examining the chromosome complement of the closely related *Oakesia sessilifolia* (L.) S. Wats. (*Uvularia sessilifolia* L.)

Plants were collected in the vicinity of Boston and the somatic chromosomes were studied in root tips. Fourteen chromosomes are present and it is possible to identify the seven types. Figure 1 (S) is a diagrammatic drawing of the seven, made to scale from camera lucida sketches.

CONCLUSION: There is no evidence that chromosome duplication or chromosome interchange are of phylogenetic importance in *Uvularia*.

Although these phenomena are known to have occurred under experimental conditions and may well occur in nature, they apparently have no direct evolutionary significance in this genus. So far as can be determined by cytological examination, specific differentiation in *Uvularia* has not involved gross differences in the number or relative size of the chromosome complement. This conclusion is strengthened by the fact that *Oakesia sessilifolia*, although usually classified in another genus, has a chromosome complement essentially identical with that of the two species of *Uvularia*. These results are of particular interest in view of the data presented in Part II, which show that *U. grandiflora* and *U. perfoliata* are well differentiated species. We do not mean to suggest that chromosome duplication and interchange are never of phylogenetic importance but merely call attention to the fact that there are groups of plants, like the genus *Uvularia* in which they are not species-forming forces.

II. A MORPHOLOGICAL SURVEY OF UVULARIA

The following morphological survey of *Uvularia grandiflora* Sm. and *U. perfoliata* L. is an attempt to present objectively, in a codified form the essential facts as to resemblances and differences within and between these two similar but distinct species. It is an attempt to reproduce in a concise manner, for non-taxonomists, the kind of data which are consciously and unconsciously used by taxonomists in the delimitation of species. Fundamental biological unit though it may be, the Linnean species is still definable only by example (definable that is in terms which carry meaning to workers in other scientific fields). Those biologists who in the herbarium and in the field have had the opportunity to study a number of such examples, have come to an appreciation of the importance of these fundamental units and to a general notion of their relative magnitude, as compared with individual differences on the one hand and generic differences on the other. There are, however, many non-taxonomists who though they do not have the time nor the training to participate in taxonomic work would like to gain a rough working knowledge of a Linnean species. If a species cannot as yet be defined in terms which are meaningful to workers in other fields of biology, one can at least present the range of variation within and between two closely related species in such a summarized form that the results may be digested in a comparatively short time.

The following pages present such a summary. It is not a taxonomic treatise on the two species. They were chosen for study not because their taxonomic position was in doubt, *but for precisely the opposite*

reason. They were taken as an example because there seemed to be a very general agreement, on the one hand that they were specifically distinct from one another, and on the other hand that they were closely related members of the same genus. As far as practical taxonomic work is concerned, the data reported below merely confirm the customary disposition of *Uvularia grandiflora* and *U. perfoliata* as two distinct species of one genus.

After a preliminary study of herbarium material 15 sheets of each species were selected from the collections at the Gray Herbarium and were subjected to intensive study. Several times as many would have been desirable but we were obliged to limit the sample in order to obtain well-developed material in which the characters chosen for study could be measured accurately. The following collections were studied:

Uvularia grandiflora

Canada: Quebec, Lake Memphremagog, dry ground, *J. R. Churchill,* Aug. 17, 1914. Vermont: Middleburg, *E. Brainerd,* May 18 - June 5, 1879; Shell House Mt., Ferrisburg, *E. and C. E. Faxon,* June 19, 1891; Hubbardston, *W. W. E.,* no. 2, July 17, 1898; Hyde Manor, Sudbury, *Geo. G. Kennedy,* May 23, 1908; Manchester, *M. A. Day,* no. 179, July 7, 1898; near Hyde Manor, Sudbury, *E. F. Williams,* May 23, 1908. New York: North Fort Ann, Washington Co., *S. H. Burnham,* May 30, 1920. Illinois: Starved Rock, La Salle Co., in rich woods, *J. M. Greenman et al.,* no. 26, June 1-7, 1909. Wisconsin: St. Croix Falls, *C. F. Baker,* July 8, 1900; *J. M. Greenman,* no. 2165, June 5, 1907. Missouri: Taney Co., rich woods, along rocky bluffs, *E. J. Palmer,* no. 19237, Sept. 29, 1920; Creve Coeur Lake, *M. W. Lyon,* June 12, 1904; Clark Co., *B. F. Bush,* no. 2, Aug. 26, 1892; Cape Girardeau Co., rich woods along Miss. River, *E. J. Palmer,* no. 17998, June 21, 1920.

Uvularia perfoliata

Massachusetts: Sudbury, *E. F. Williams,* no. 1, May 30, 1900; Sudbury, *E. F. Williams,* no. 1, May 30, 1900; Granville, Hampden Co., deep rich, deciduous wood, *F. C. Seymour,* no. 191, June 24, 1914; South Georgetown, open woods, *E. F. Williams,* Aug. 1, 1899. Connecticut: Southington, shade, *L. Andrews,* no. 358, June 3, 1898; Cromwell, *E. Wright,* June 7, 1878. New York: Tompkins Co., in woods, *A. Gershoy,* no. 7845, June 27, 1917; South Nyack, *L. M. S.,* June 2, 1888. Pennsylvania: Berks Co., woods, eastern slope, *H. B. Meridith,* June 14, 1922; Delaware Co., woods,

A. MacElwee, no. 97567, June 16, 1899. New Jersey: Somerdale, Camden Co., rich wooded slope, *H. B. Meridith*, May 27, 1921. Virginia: Bedford Co., *A. H. Curtiss*, Aug. 26, 1871. District of Columbia: Washington, *E. S. Steele*, May 4, 1896. North Carolina: Waynesville, *E. E. Magee*, June 9, 1897; Asheville, *B. L. Robinson*, no. 75, Aug. 2, 1893.

A number of interesting characters could not be studied, either because they were poorly preserved or because they were present on only a few of the sheets. For these reasons no detailed observations are reported on roots, seeds, fruits, and scale leaves (cataphylls).

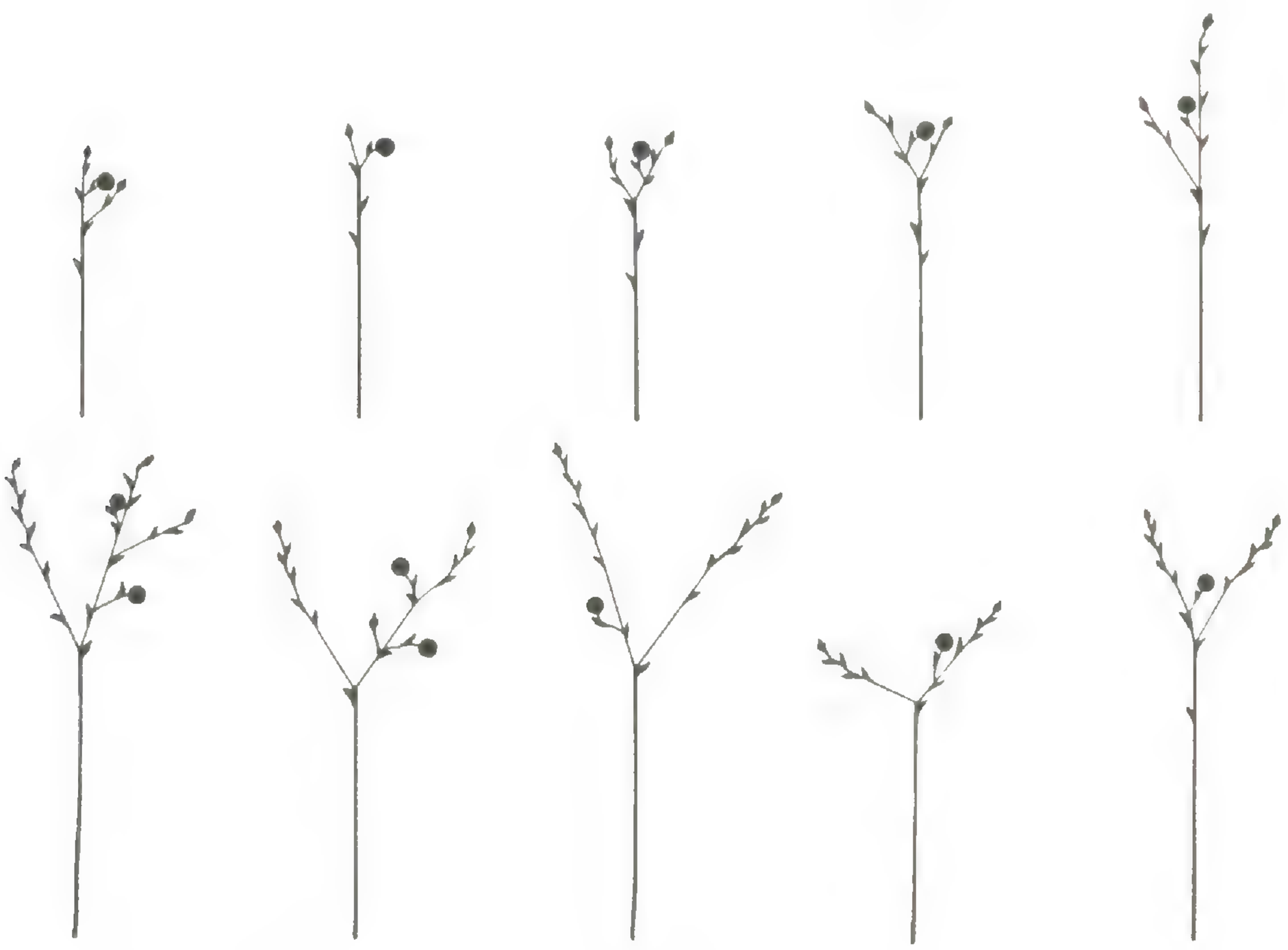

FIGURE 2. Diagrams, to scale, showing node number, etc. in 5 specimens of *U. perfoliata* (above) and 5 of *U. grandiflora* (below). Further explanation in the text.

STEM.

Five flowering specimens of each species are shown diagrammatically in Figure 2. A few poorly preserved details (such as the number of scale leaves at the base of the stem) have been ignored. The drawings are made to scale so far as internode lengths are concerned, and the angles of the branching have been approximately reproduced. The representations of the leaves and flowers are purely conventional. A

study of Figure 2 reveals the following differences between the two species.

A. *U. grandiflora* is somewhat larger, on the whole.
B. *U. grandiflora* has fewer nodes below the lowest branch.
C. *U. grandiflora* has more nodes on the lowest (sterile) branch.
D. *U. grandiflora* has a higher average number of flowers per plant.
E. In *U. grandiflora* the upper end of the main axis is less perpendicular than in *U. perfoliata*.

TABLE II.

Number of nodes	0	1	2	3	4	5	6	7	8
Number of nodes with leaves below branch									
U. perfoliata			5	9	1				
U. grandiflora		7	8						
Number of nodes on sterile branch									
U. perfoliata		1	9	4	1				
U. grandiflora					1	4	7	1	2

Of these five differences, B and C are relatively unaffected by the age of the plant and can be readily ascertained from herbarium specimens. They were chosen accordingly for more extensive investigation and are recorded in Table II, for all of the specimens under consideration. It will be seen that when a number of specimens are considered that neither character is discontinuous. This is true of all five of the characters of the stem enumerated above. After a little study any single specimen could be correctly placed, by a combination of these five characters, no one of which would suffice, if taken separately.

LEAVES.

Tracings of leaf outlines from the same five specimens are presented in Figure 3. To make the comparison more exact a particular leaf was

chosen, namely, the leaf located at the axis of the main branch and the fertile shoot.

The following differences, or tendencies to differ, can be found between leaves of the two species.

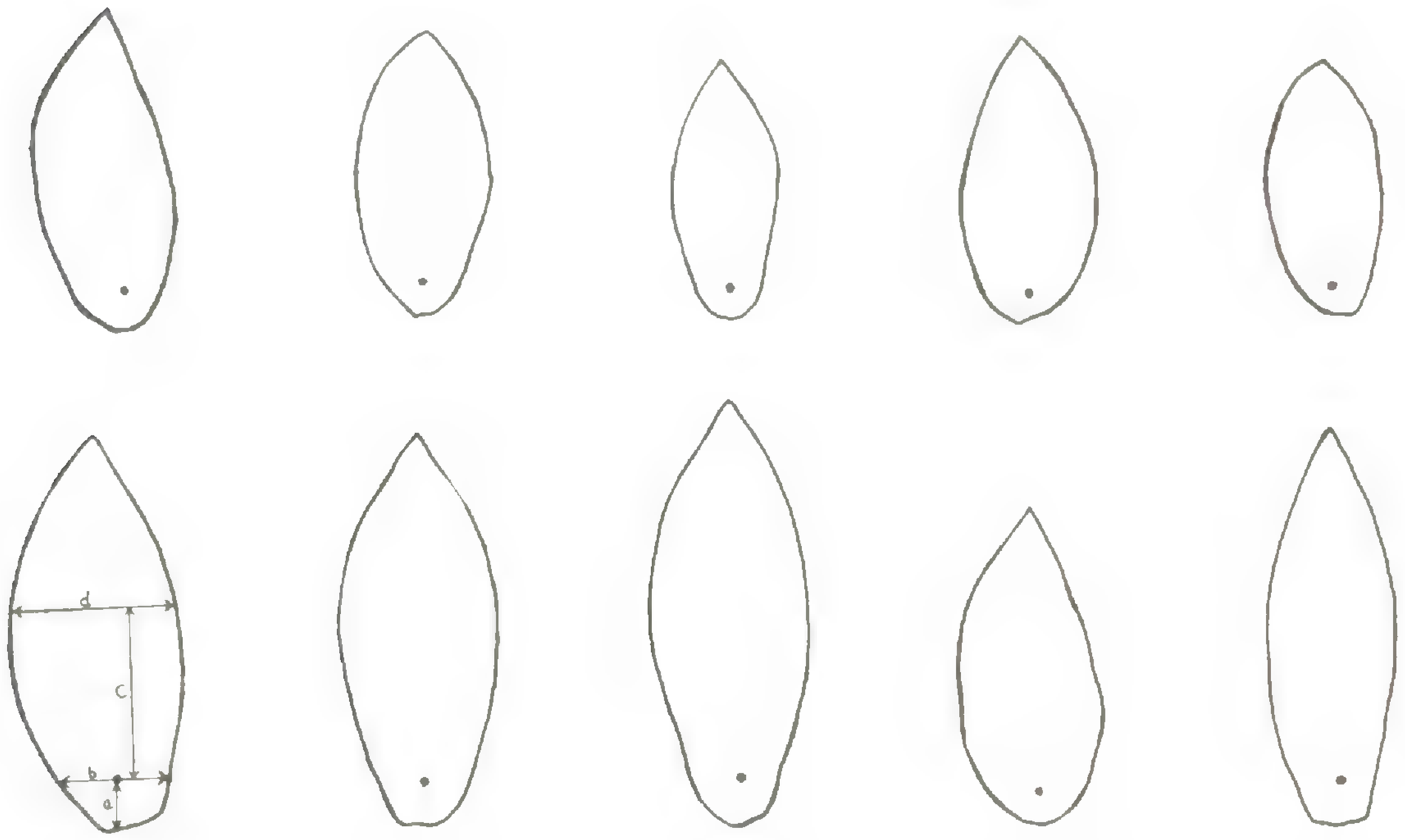

FIGURE 3. Leaf outlines from five specimens of *U. grandiflora* (above) and five of *U. perfoliata* (below). The four features measured are shown on the lower left hand specimen.

A. The leaf of *U. grandiflora* is a little larger on the average.

B. The leaf of *U. grandiflora* has a strong tendency towards something like the outline of a wooden shoe, with a narrow diameter through the heel and a broad one through the sole. This was made the subject of a more extended investigation, the results of which are reported in a later section.

C. The leaf of *U. grandiflora* is usually pubescent on the under side. That of *U. perfoliata* is usually glabrous. Microphotographs of the leaf surfaces of 4 specimens of each species are shown in Plate 82. While this difference is a discontinuous one for the material considered in the present study, it would probably lose its discontinuity if a larger series of each species were examined. The specimen from Creve Coeur Lake, Missouri, was practically glabrous though it was in other respects a typical plant of *U. grandiflora*. Nor is there any evidence that it might have resulted from hybridization. The region in which it was collected

is far outside the natural range of *U. perfoliata* and the particular locality is a semi-public reservation in which the original vegetation has been practically undisturbed.

D. *Uvularia grandiflora* has usually three veins in the leaf which are much larger than the rest. In *U. perfoliata* there are large veins and small ones, but there are seldom three which are clearly of another order of size than the remainder.

FLOWERS.

Photographs of representative flowers are shown in Plate 83. They exhibit a number of differences which are characteristic of the two species. If the flowers could be more easily examined without injury to the specimens, several of these characters would have been studied statistically. A survey of the 30 sheets shows the following differences.

A. *Uvularia perfoliata* has large glandular outgrowths on the side of the perianth segments. These outgrowths are not present in *U. grandiflora.*

B. In *U. grandiflora* the style is much longer in proportion to the stamens than in *U. perfoliata.*

C. The perianth segments of *U. grandiflora* are longer on the average. The actual extremes were 2.4 — 4.7 cm. in *U. grandiflora* and 2.4 — 3.6 cm. in *U. perfoliata.* The respective medians for 7 specimens of each species are 3.2 and 2.7 cm.

D. The stamens of both species have a pointed sterile tip. This tip is on the average much longer in *U. perfoliata.*

STATISTICAL ANALYSIS OF DIFFERENCES IN LEAF SHAPE.

Four measurements were taken on each leaf, the points to be measured having been chosen in such a way as to include the most outstanding differences in leaf shape between the two species. The four distances measured are indicated for the lower left-hand leaf of Figure 3. In interpreting this diagram it should be remembered that the leaf of *Uvularia* is perfoliate. The four measurements may be defined as follows:

a. The distance from the stem to the rear margin of the leaf, along the median line.

b. The width of the leaf at the stem.

c. The distance from the stem to the point of maximum width.

d. The maximum width at right angles with the mid vein.

The results are summarized in Table III. It will be seen that as far as absolute values are concerned, that there is very little difference

between the two species. Quite another picture is presented by the ratios between these four measurements. There are six possible ratios and they are summarized in Table III. It will be seen that though in every case the two species overlap, their averages are quite different.

The three ratios in which the two species differ most markedly are a/d, b/c, and b/d. It was desired to utilize all three and in some way combine them into a simple ratio or index which would measure simultaneously all three ratios. This was done quite simply by use of the following formula: leaf index =

$$\sqrt{\left(\frac{a}{d}\right)^2 + \left(\frac{b}{c}\right)^2 + \left(\frac{b}{d}\right)^2} \cdot$$

Figure 4 shows graphically the significance of the leaf index in terms of analytical geometry. Analytically the index is a diagonal through a box, each dimension of which is determined by one of the three ratios. The ratio a/d determines the width of the box, the ratio b/c its height, and the ratio b/d its depth. Since *U. grandiflora* on the whole has

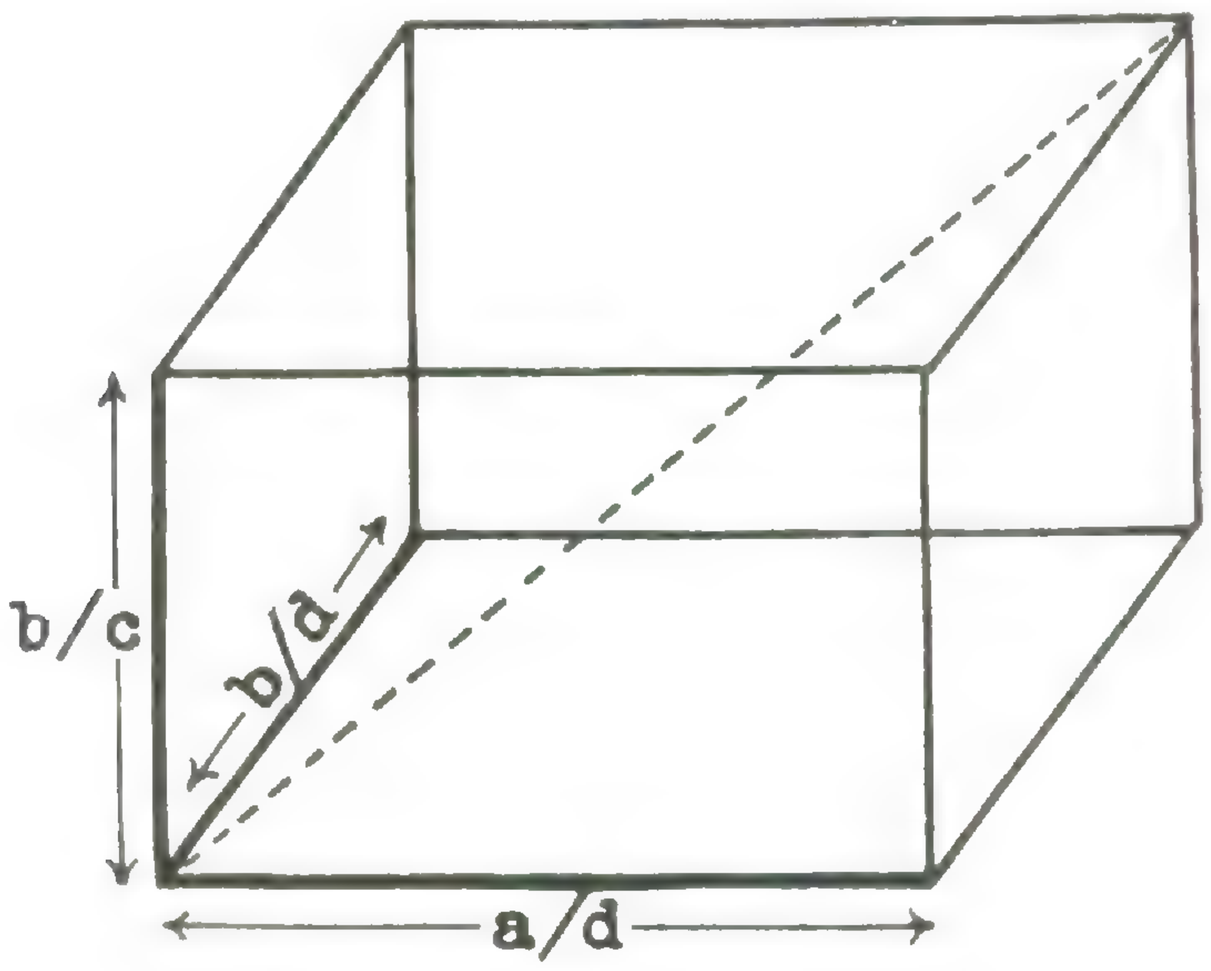

FIGURE 4. Explanation in the text.

lower values for all three ratios, the "boxes" are generally smaller, and the diagonals through these "boxes" generally shorter than is the case in *U. perfoliata*. The calculated values for the leaf index are collected in Table III. While they still give an overlapping distribution for the two species, they come much nearer to separating them than does any simple ratio taken by itself.

By the addition of two values calculated from characters of the stem, we can separate the specimens statistically. To accomplish this in a

simple way, we need characters for which the values of *U. perfoliata* are usually higher than those of *U. grandiflora* and which have a range of values roughly similar to those of the three leaf ratios (0.1 to 1.3). Characters fitting these requirements were obtained from, (1) the number of leaves below the lowest branch, and (2) the number of leaves on the sterile branch. In the case of the first, the actual number of leaves was divided by 10 and multiplied by 2, yielding values from 0.2 to 0.4 for *U. grandiflora* and from 0.4 to 0.8 for *U. perfoliata*. The new scale for the second character was obtained by subtracting the leaf number from 10 and dividing the result by 10. This yielded values of 0.2 to 0.6 for *U. grandiflora* and 0.6 to 0.9 for *U. perfoliata*. These two

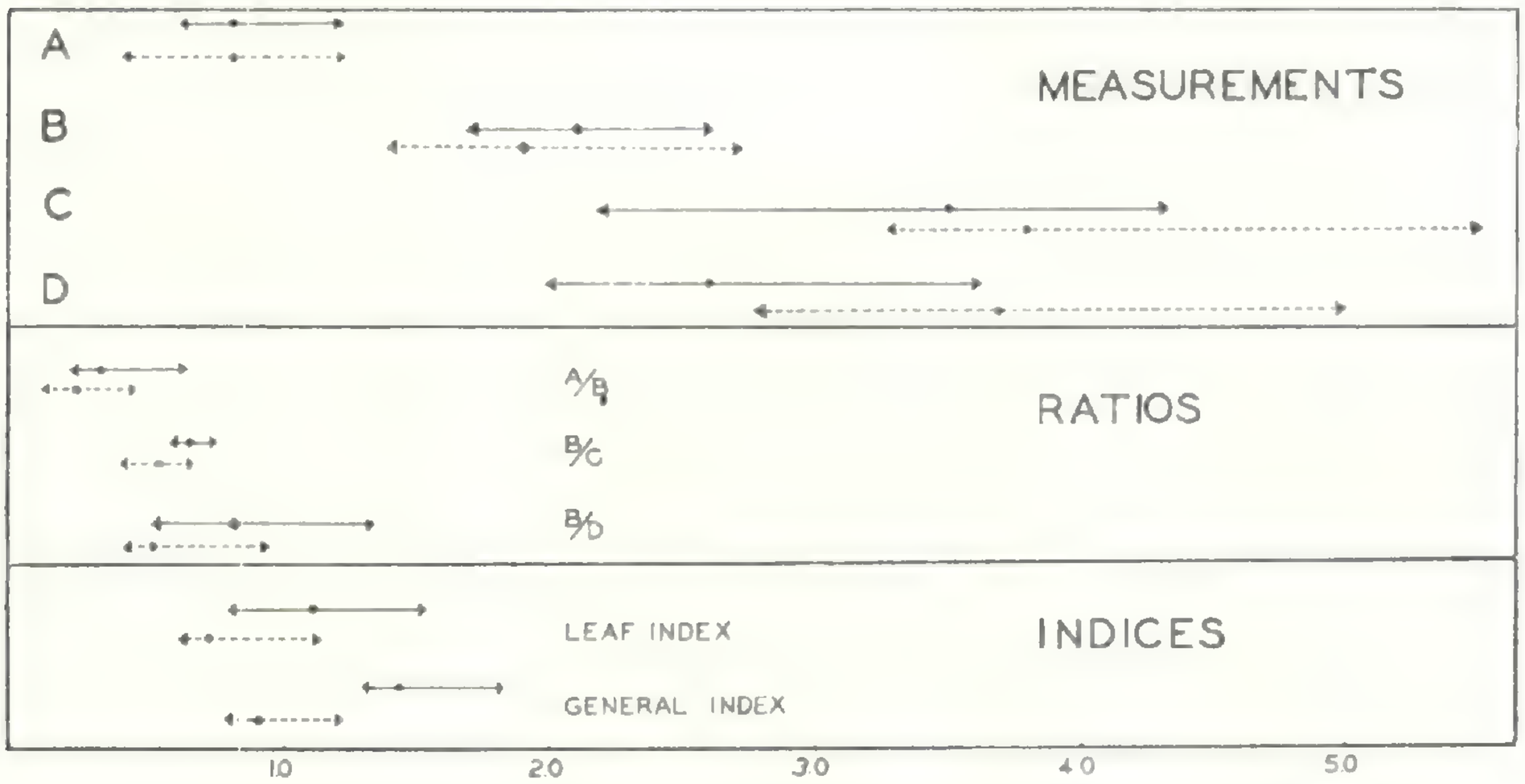

TABLE III. Variation in leaf measurements, ratios of measurements, and index numbers for 15 specimens each of *U. grandiflora* (dotted lines) and *U. perfoliata* (solid lines). The arrows show the limits of variation and the dots the position of the average values.

values may be added to the three ratios in the same simple way that was used in building up the leaf index, to form what we may call for lack of a better term the "General Index."

$$\text{General Index} = \sqrt{(a/d)^2 + (b/c)^2 + (b/d)^2 + (1)^2 + (2)^2}$$

Analytically we are still dealing with diagonals and although they are diagonals in multi-dimensional space, they are still capable of linear measurement, and the lengths of these diagonals may be grouped on a single scale as we have done in Table III.

It will be seen that the values of the "General Index" are completely discontinuous. In other words we have demonstrated statistically the

same point that was brought out in the graphical analysis of differences in the branching of the stem. *The species in question may be separated by a combination of tendencies even when none of these tendencies, taken by itself, will suffice.*

Quite as important as the morphological differences in a presentation

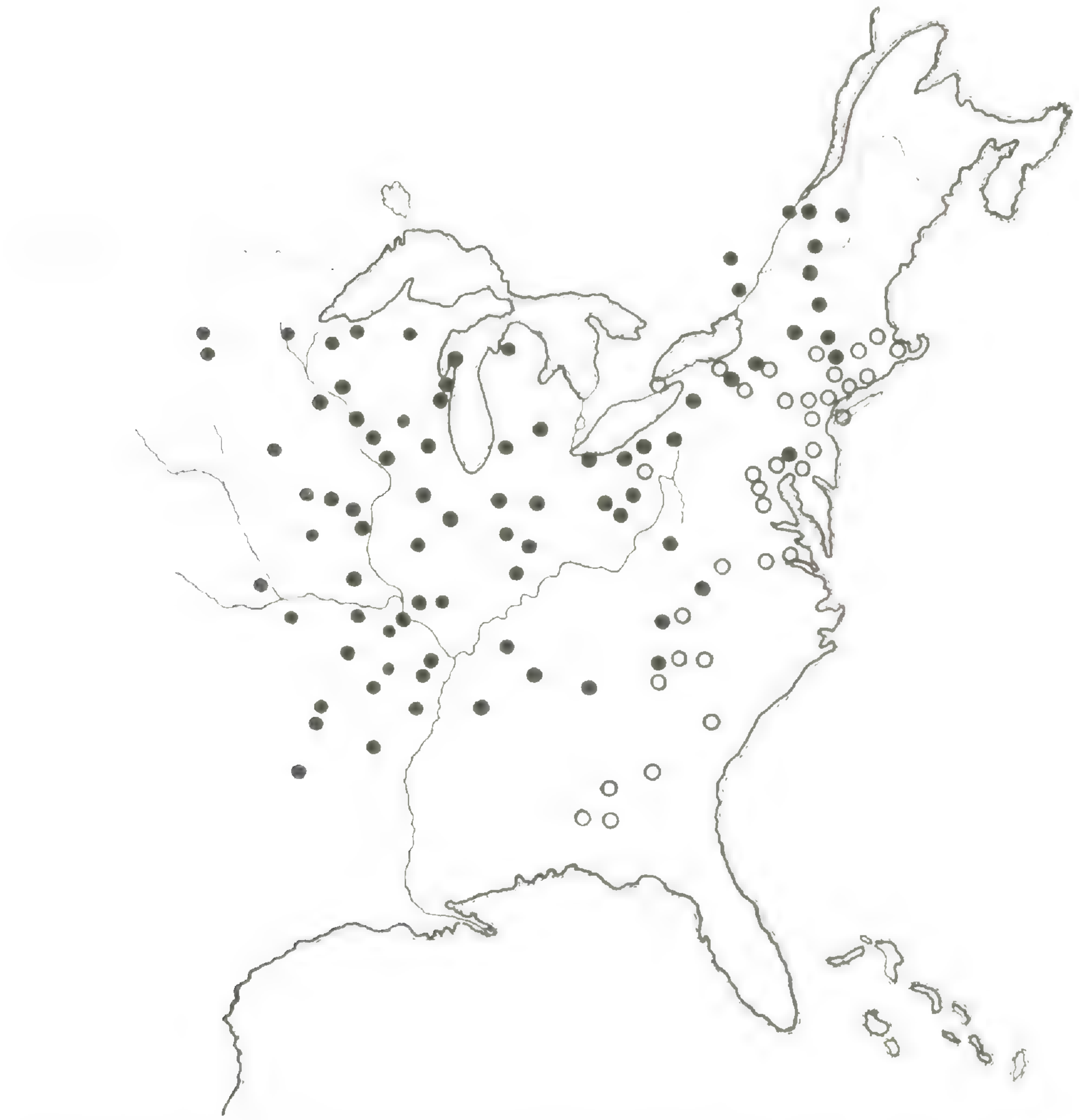

FIGURE 5. Distribution of *U. perfoliata* (open circles) and *U. grandiflora* (black dots).

of specific characteristics are physiological ones. For the most part they cannot be studied effectively with herbarium material. That they exist has been shown by Wiegand and Eames (1925) in their report on the two species in their "Flora of Cayuga Lake Basin." They state that *U. perfoliata* flowers two weeks or more later than *U. grandiflora*

and that it is found in "sandy acid or subcalcareous soil" while *U. grandiflora* grows in "gravelly or alluvial calcareous rich soils."

The ranges of species are in part, at least, determined by their physiological constitution. This point can, of course, be investigated with herbarium material and the distributions of the species of *Uvularia* as determined by that method are shown in Fig. 5. It will be seen that throughout the general calcareous areas of the Middle West, *Uvularia grandiflora* is a common species while in New England it penetrates only to the limestone areas of western Vermont. *U. perfoliata* conversely is a fairly common plant in New England and is found southward mainly along the mountains. There is an appreciable area where the two ranges overlap but for the most part they occupy different situations within that area.

Discussion.

The above comparison of *Uvularia perfoliata* and *U. grandiflora* has shown four differences in the leaves, five in the nodes, and four in the flowers. Fundamental physiological differences were indicated by habitats and ranges, other morphological differences are known to exist in characters not available for study in our material. Of all the above differences, only three were discontinuous and there were indications that at least one of these would not have remained so if a larger series of specimens could have been examined. In the case of the intergrading differences, the two species could be separated by compounding several, no one of which would be sufficient if considered by itself.

If one attempts to think in general terms of the total hiatus between *U. grandiflora* and its nearest relative, he reaches a conception of specific differences as a combination of many minor tendencies. *The acknowledged discontinuity between the two species, taken in their entirety, is a discontinuity of combinations, reinforced by a few discontinuous differences in single characters.*

It does not seem to be generally realized that species may be, and customarily are, thought of in two quite different ways by different groups of biologists. Those biologists engaged in purely taxonomic work will unavoidably think of species in terms of the precise differences which permit their ready classification; which make it possible to arrange species in an herbarium or to construct a morphological key to a genus. To them the really essential differences between *U. grandiflora* and *U. perfoliata* will be those few discontinuous ones which are ordinarily used in identifying the species.

With this attitude of mind the present authors have no quarrel recognizing taxonomy as a difficult and necessary business, and that those who have it in hand are to be thanked for doing the work and must be allowed to develop their own methods of going about it.

On the other hand there are those who are interested not so much in the technical nature of the classifying process as in the biological make-up of the units which are being classified. This group will include some taxonomists, for the separation of the two lines of thought is not absolute.

To us, members of the latter group, the difference between two species is the difference between one kind of germ-plasm and another. As geneticists currently think of germ-plasms made up of an enormous number of separate units, so the difference between species, even between very closely related species, will be the resultant of a large number of minor differences. The seat of these differences is certainly the individual cells and will be expressed not in any one or two characters. It will extend throughout the plant, being more sharply manifest in some parts than in others.

From this point of view such tenuous characters as aspect and texture may have a very real biological basis. The characteristic leaf texture of a particular species, for instance, is ultimately dependent upon the size, form and arrangement, of the cells which make up the leaf. If the cells are small and regularly arranged, the leaf will have a close even surface; when the cells are irregular and large, the surface will be coarse and rough. Differences in aspect may in a similar way be traced back to the reactions of different germ-plasms.

Such specific differences, though slight and subtle, will on the whole manifest themselves similarly throughout the plant. Those internal forces which tend to produce small regular cells in the leaf will generally have a similar effect in the stem, and in the flower. The late Edward L. Greene has been credited with having separated species on the basis of "a certain indescribable grace." He may have been a good biologist, though a poor taxonomist, in relying on that distinction as an evidence of specific difference.

To us the many slight overlapping differences between species are more characteristic than the few sharply discontinuous ones. If we were forced to summarize the many differences between these two species of *Uvularia* in the fewest possible words, we could do no better than to say that *U. perfoliata* is neater and more delicate than *U. grandiflora*. In this way we might pack into a single phrase something

of the impression we have gained of two different life-stuffs, each of which reacts variously with the environment. Individual plants produced cooperatively by the germ-plasm and the environment, will show only one facet of the possibilities of that germ-plasm. For the full expression of the capabilities of a particular species there will be required a whole series of individuals produced under various environments.

SUMMARY

Part I.

1. Differentiation of species in the genus *Uvularia* has not involved gross differences in the number or relative sizes of the chromosomes.

Part II.

2. *Uvularia perfoliata* and *U. grandiflora* were chosen for a study of the nature of specific differences. A summary is presented of such differences as can be investigated in herbarium material.
3. A statistical method is described which compounds two or more separate measures into a single index. By the use of this method it is possible to separate the two species by a combination of characteristics, no one of which would suffice if considered separately.
4. The nature of specific differences is discussed in the light of these results.

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EXPLANATION OF THE PLATES

Plate 82

Lower leaf surfaces (× ±6) of *Uvularia grandiflora* ('G') and *U. perfoliata* ('P'). The leaves in order from top to bottom are from the following 4 collections:

Lyon s.n. 6/12/1904
Palmer 17998
Palmer 19237
Greenman 2165

The leaves of *U. perfoliata* are from the following 4 collections:

Wright s.n. 6/7/1878
Williams s.n. 8/1/1899
Williams s.n. 5/30/1900
Meridith s.n. 5/27/1921

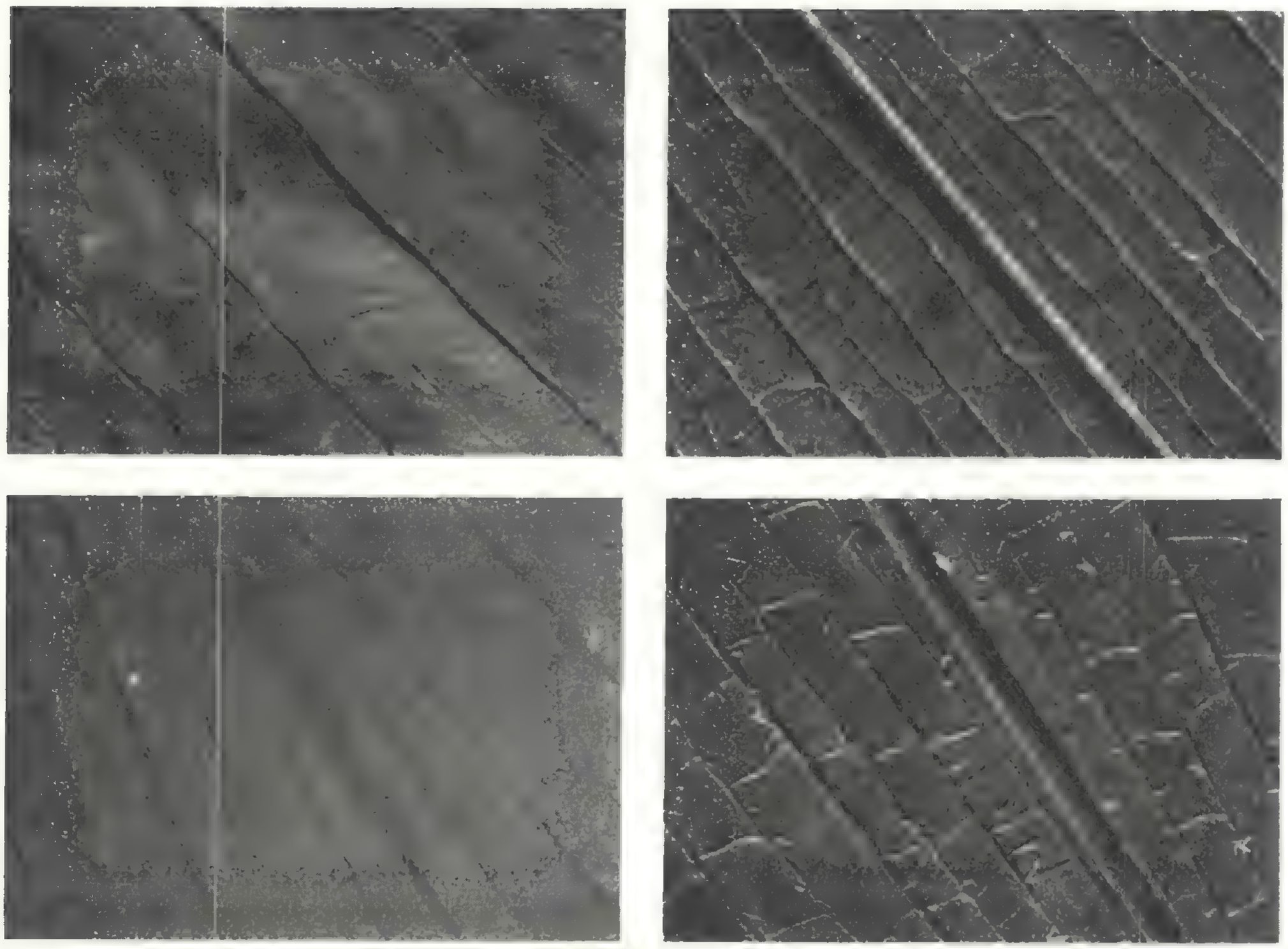
The reader's attention is called to the fact that this Plate is not so much a demonstration of points made in the paper as an attempt to present an objective summary of one kind of specific difference (namely leaf-texture). So far as possible the same lighting, magnification, and photographic development have been used throughout. The lack of sharpness in the cuts of *U. perfoliata* is not inferior photography; it is due to the fact that that species has a smooth leaf with a somewhat waxy surface. The photographs demonstrate a point which is in line with the main contention of the paper, viz., that the leaves are more easily distinguished by their general texture and appearance than by the single technical character (presence or absence of hairs) which is customarily used in keys and descriptions.

Plate 83

Enlarged photographs (×6) of *Uvularia* flowers from herbarium specimens. The stigmas have been retouched with India ink.

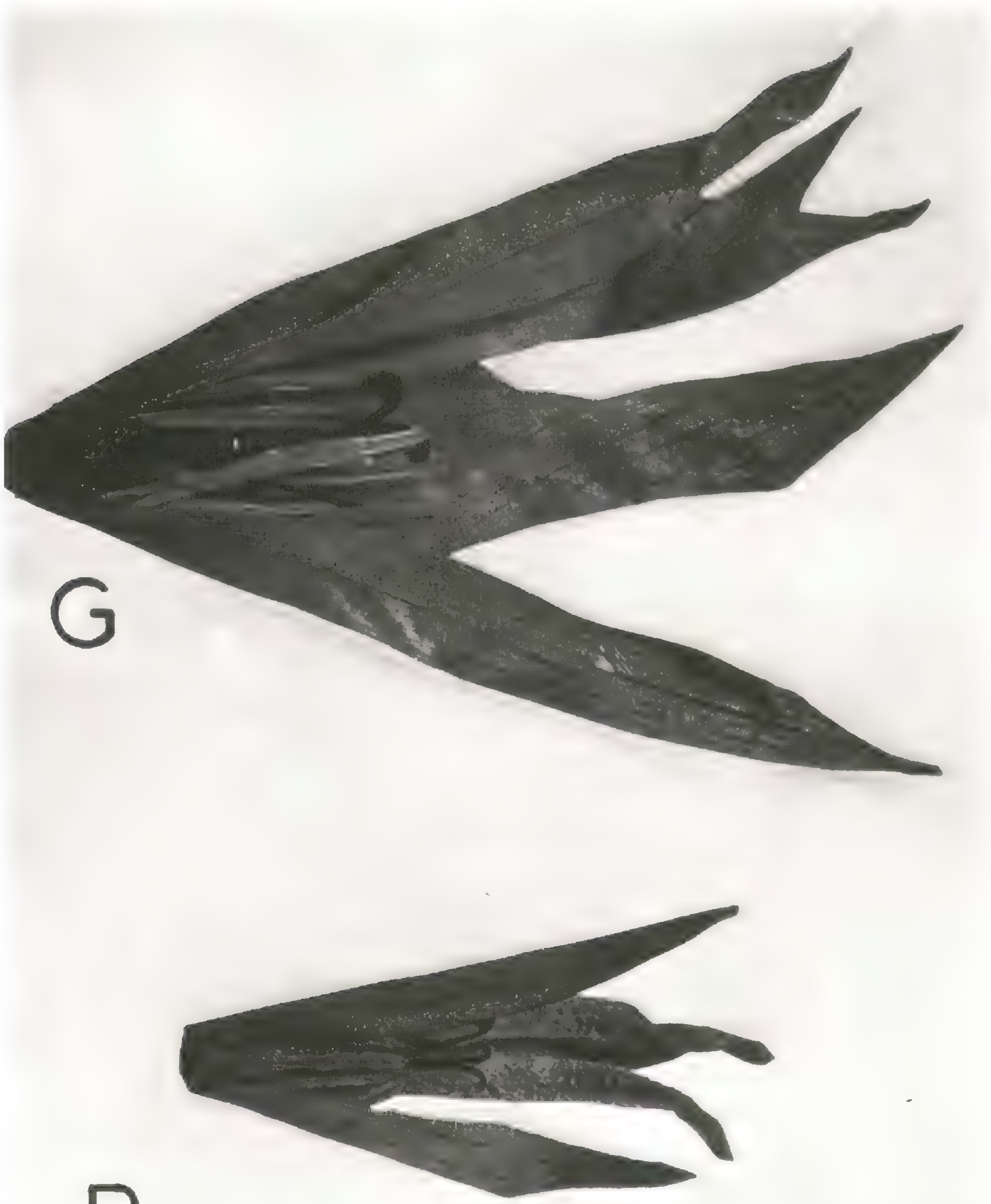
'P' = *U. perfoliata* (from Burnham s.n. 6/2/1907 Lake George, N. Y.)
'G' = *U. grandiflora* (from Williams s.n. 5/22/1908 Brandon, Vt.)

ARNOLD ARBORETUM,
HARVARD UNIVERSITY.



P G

Speciation in Uvularia


G
P

A QUANTITATIVE COMPARISON OF SPECIFIC AND GENERIC DIFFERENCES IN THE BETULACEAE

EDGAR ANDERSON AND ERNST C. ABBE

With one text figure

THE CRITERIA on which the sciences of Morphology and Taxonomy are largely based have two disadvantages. They are not objective and they are not commensurable. The first of these difficulties may be resolved through improvements in morphological technique. Such simple qualitative categories as "ovate" or "obovate" are already quite as objective as the quantitative measures of chemistry or physics. Through closer analysis and more exact definition it may eventually be possible to bring the larger categories of taxonomy to a comparable degree of objectivity. Even with this improvement, the second difficulty would still remain; the categories are not reducible to a common basis. Is, for instance, the change from an ovate leaf to a lanceolate one, greater or smaller than the change from a lanceolate leaf to a linear? How do the differences between subgenera compare to generic differences on the one hand and specific differences on the other? To such questions as these the qualitative units of morphology permit no precise answers.

The following paper is a crude first attempt to work out a commensurate method for dealing with such morphological and taxonomical problems. It is an attempt to carry on consciously and mathematically the same sort of process which with a good naturalist is subconscious and unmathematical. When a naturalist distinguishes between two species which are well known to him, he subconsciously takes the component of a very large number of variables. He knows *Acer rubrum*, for instance, not by any one technical distinguishing feature, but by the total impression of a very large number of features, any one of which may vary considerably in different individuals of *Acer rubrum*. In mathematical phraseology, his generalized idea of an *Acer rubrum* is the *largest common denominator* of all the individuals he has previously recognized as belonging to that species. Any biologist who has had practical field experience with a species or a genus will probably agree with this definition. A slightly more objective demonstration

will be found in a recent survey of specific differences in *Uvularia* (Anderson & Whitaker, 1934).

If such a process is to be made conscious and turned into commensurate units, we must attempt as far as possible to carry on the same sort of procedure mathematically. We must select a large number of features for measurement, features which by previous analysis are known to be individually significant, and then determine their aggregate effect mathematically. This paper is an attempt to measure the relative magnitudes of various categories in the Betulaceae by such a method. Six features are chosen and their aggregate effect is calculated by a comparatively simple method whose essential features have been described elsewhere (Anderson & Whitaker, 1934). The significance of such an index calculated from diverse components may be made clear by a comparison with well-known indices in other fields. As a measure of business activity it is common practice to combine diverse categories such as car-loadings per week, electric power output, and the price of food-stuffs. With an intrinsically meaningless scale of this type, we measure the rise and fall of business from week to week or contrast the condition in one part of the country with that in another. In just such a way there are combined in the following analysis, six features of known importance in the Betulaceae:

1: the basic chromosome number
2: the number of perigon segments in the female flower
3: the average number of stamens per flower
4: the total number of bracts in a bract-complex
5: the number of flowers per pistillate bract-complex
6: the maximum number of cell rows in the rays of the secondary xylem.

Table I shows the actual data used for the 40 species of the Betulaceae for which figures were readily available. It should be noted, however, that in the case of the perigon segments of the ovary, in the number of bracts in a bract-complex, certain factors must be taken into account. Thus there is anatomical evidence for the presence of vestigial perigon segments in the pistillate florets of some species of *Alnus* (Abbe, 1933). In the absence of a satisfactory means of indicating this mathematically they have been uniformly treated as indicated in Table I. The number of stamens per floret introduces perhaps the most variable character possessed by the members of the family. Here the data are based on representative individuals rather than on a mathematical average. These individuals have been chosen to illustrate the

TABLE I*

Genus & Species	Basic Chromosome No.	No. of (Female) Perigon Segments	No. of Stamens per Floret	Total No. of Bracts per Staminate Bract-Complex	No. of Florets per Pistillate Bract-Complex	Maximum No. of Cell Rows in the Ray
Alnus						
§ALNOBETULA						
A. crispa	7	0	5	4	2	1
§GYMNOTHYRSUS						
A. incana	7	0	4	5	2	1
A. cordata	7	0	4	5	2	1
A. maritima	7	0	3	5	2	1
A. rhombifolia	7	0	3	5	2	3
A. hirsuta	7	0	4	5	2	1
A. rubra	7	0	4	5	2	1
Betula						
§EUBETULA						
§§COSTATAE						
B. nigra	7	0	2	3	3	4
B. utilis	7	0	2	3	3	2
B. Schmidtii	7	0	2	3	3	3
B. grossa	7	0	3	3	3	3
B. costata	7	0	3	3	3	3
B. lenta	7	0	3	3	3	4
B. lutea	7	0	3	3	3	4
§§Nanae						
B. Michauxii	7	0	1	3	1	1
B. pumila	7	0	2	3	3	3
§§Albae						
B. pendula	7	0	2	3	3	3
B. japonica	7	0	2	3	3	3
B. populifolia	7	0	2	3	3	3
B. pubescens	7	0	2	3	3	4
B. papyrifera	7	0	2	3	3	3
B. davurica	7	0	2	3	3	3
§BETULASTER						
§§ACUMINATAE						
B. Maximowicziana	7	0	3	3	3	3
B. alnoides	7	0	2	1	3	3
Corylus						
C. Avellana	7	4	2	3	2	1
C. americana	7	4	2	3	2	1
C. heterophylla	7	4	2	3	2	1
C. Colurna	7	4	2	3	2	1
C. cornuta	7	4	2	3	2	3
Ostryopsis						
O. Davidiana	8	4	2	1	2	1
Carpinus						
§DISTEGOCARPUS						
C. japonica	8	4	6	3	2	4
C. cordata	8	4	6	1	2	3
§EUCARPINUS						
C. betulus	8	4	4	1	2	4
C. caroliniana	8	4	4	1	2	3
C. laxiflora	8	4	3	1	2	3
C. Tschonoskii	8	4	3	1	2	3
C. orientalis	8	4	4	1	2	2
Ostrya						
O. virginiana	8	4	4	1	2	3
O. japonica	8	4	4	1	2	2
O. carpinifolia	8	4	3	1	2	2

*The specific names are based on Rehder (1927). The subgenera, etc., are based on Winkler (1904).

salient trends of differentiation within the group. While the number of bracts in a given staminate bract-complex is generally a relatively constant character for a genus or a species, it sometimes, as in *Alnus crispa* and *Carpinus japonica,* is variable. Here again it has been necessary to choose a significant figure, in the absence of averages. The basic chromosome numbers are taken from Woodworth (1931). The differences between species were calculated from the data in Table I by the formula:

TABLE II

SUMMARY OF INTRAGENERIC, INTRASECTIONAL DIFFERENCES

Names of Genera and Sections	Range of Differences 0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0	5.1-6.0	6.1-7.0	Total	Av'g
ALNUS §Gymnothyrsus	10	1	4					15	1.0
BETULA §§Costatae	12	7	2					21	1.2
" §§Nanae			1					1	3.0
" §§Albae	15							15	.3
" §§Acuminatae			1					1	2.2
CORYLUS	6	4						10	0.8
CARPINUS §Distegocarpus			1					1	2.2
" §Eucarpinus	5	5						10	1.2
OSTRYA	2	1						3	1.1

SUMMARY OF INTRAGENERIC, INTERSECTIONAL DIFFERENCES

ALNUS									
§Alnobetula—§Gymnothyrsus		4	2					6	1.8
BETULA									
§§Costatae—§§Nanae	5	4	3	2				14	2.2
" —§§Albae	29	13						42	1.0
" —§§Acuminatae	5	3	6					14	1.5
§§Nanae—§§Albae	6		5	1				12	1.6
" —§§Acuminatae	1	1		2				4	2.5
§§Albae—§§Acuminatae	5	6	1					12	1.6
CARPINUS									
§Distegocarpus—§Eucarpinus		1	6	3				10	2.9

SUMMARY OF INTERGENERIC DIFFERENCES

ALNUS—BETULA			6	15	4			25	3.5
" —CORYLUS					18	7		25	5.0
" —OSTRYOPSIS						2	5	7	6.0
" —CARPINUS						13	12	25	6.1
" —OSTRYA						20	1	21	5.8
BETULA—CORYLUS					20	5		25	4.8
" —OSTRYOPSIS					3	14		17	5.2
" —CARPINUS					10	12	3	25	5.2
" —OSTRYA					9	16		25	5.1
CORYLUS—OSTRYOPSIS			5					5	2.4
" —CARPINUS			3	14	6	2		25	3.6
" —OSTRYA			6	9				15	3.1
OSTRYOPSIS—CARPINUS			4	1	1	1		7	3.3
" —OSTRYA		1	2					3	2.1
CARPINUS—OSTRYA	10	5	3	3				21	1.6

$$\text{Aggregate difference} = \sqrt{\Delta_1^2 + \Delta_2^2 + \Delta_3^2 + \Delta_4^2 + \Delta_5^2 + \Delta_6^2}$$

Thus the aggregate difference between *Alnus cordata* and *Alnus maritima* is calculated from the data in Table I as follows:

$$\sqrt{(7-7)^2+(0-0)^2+(4-3)^2+(5-5)^2+(2-2)^2+(1-1)^2}$$
$$=\sqrt{0+0+1+0+0+0}$$
$$=\sqrt{1}=1.0$$

The difference between *Alnus cordata* and *Carpinus japonica* becomes:

$$\sqrt{(7-8)^2+(0-4)^2+(4-6)^2+(5-3)^2+(2-2)^2+(4-1)^2}$$
$$=\sqrt{1+16+4+4+0+9}$$
$$=\sqrt{34}$$
$$=5.83$$

Analytically the magnitude of the difference is the length of a line between two points each of which is defined in six dimensions. Mathematically it would not be necessary to give the index a graphical interpretation, but many biologists find it easier to think geometrically than arithmetically.

In Table II, the magnitudes of the differences between the various species are tabulated and summarized. They are considered within sections of the genera, between sections within genera, and between genera. For the inter-specific comparisons all the possible combinations were calculated when the numbers of species in the genera under comparison were small. In the larger genera, 25 comparisons were chosen by chance, and the average calculated from these choices.

Table II shows a number of interesting facts:

1. The differences between genera are of greater magnitude than the differences within genera.

2. The differences between species within the same section are of relatively the same magnitude throughout the Betulaceae. The average difference in *Ostrya,* on the scale of the index, is 1.1; in *Betula,* 0.8; in *Carpinus,* 1.2; in *Corylus,* 0.8; in *Alnus* it is 1.0. This is an indication that the qualitative work of the taxonomists and morphologists who have dealt with the group has been surprisingly constant from genus to genus. This is particularly interesting in view of the fact that the six features used in computing the index are far from identical with those used in taxonomic work. Two of them indeed (Nos. 1 and 6) bear no direct relationship thereto.

Using the average distances between genera as obtained in the last column of Table II, a three-dimensional model was constructed. Just as the distance between any two points can be represented on a single straight line, but the distances between any three may require a plane for graphical representation, so in this problem we are entitled to five dimensions to show the relationships between our six genera. Fortunately the relationships are simple enough so that three dimensions will give a working approximation. A study of the model reveals sev-

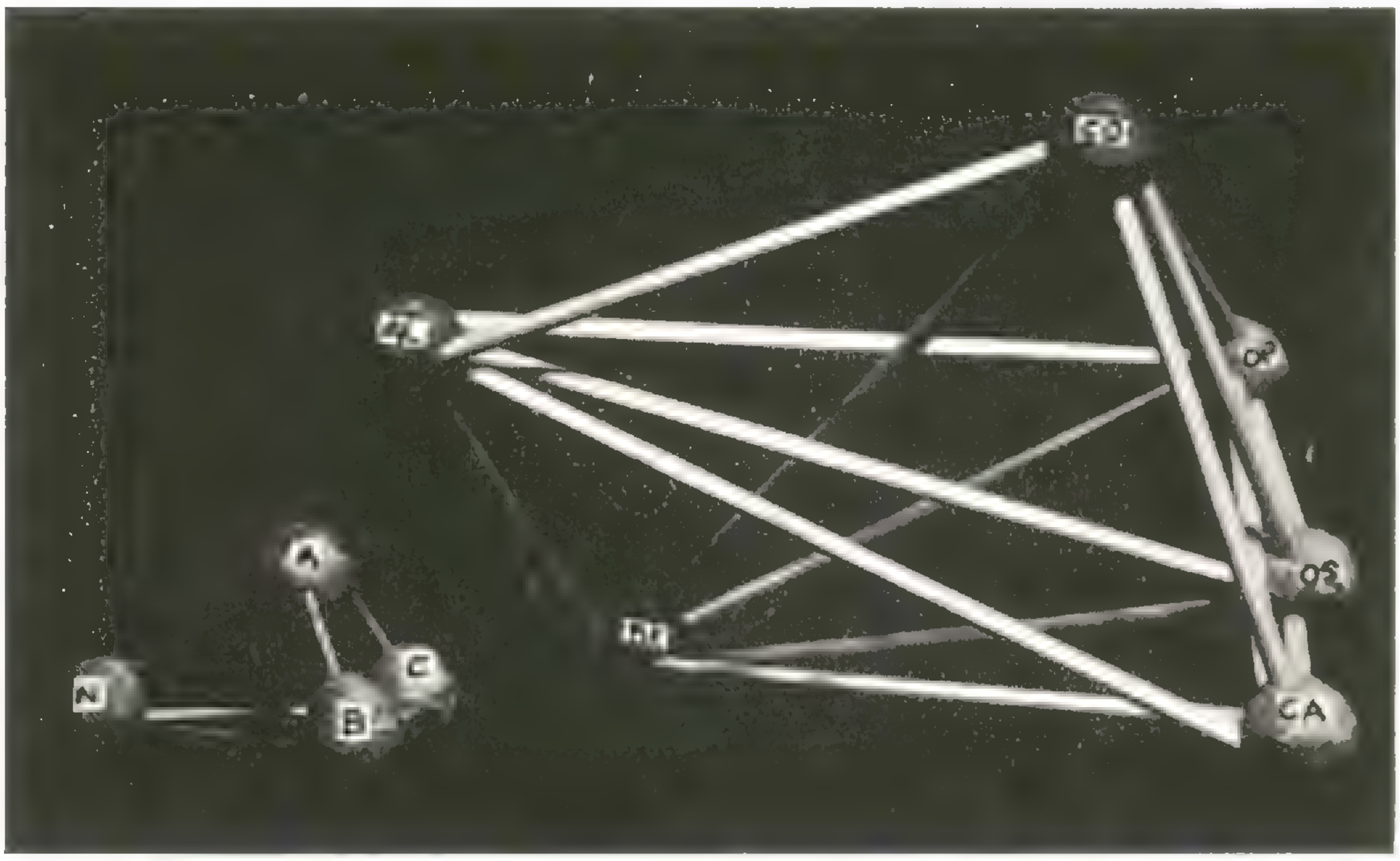


FIGURE 1. Models showing the comparative distances between the genera of the Betulaceae and the sub-sections of the genus *Betula*. For the larger model, AL, *Almus;* CA, *Carpinus;* CO, *Corylus;* OP, *Ostryopsis;* OS, *Ostrya*. For the smaller model, N, §§*Nanae;* A, §§*Albae;* B, §§*Acuminatae;* C, §§*Costatae*.

eral interesting points (Fig. 1). It should be borne in mind that the lines connecting genera in the model are not meant to diagram phylogenetic lines of development. They indicate nothing more than comparative distances between genera as determined by the method developed above.

(1) There are two groups of genera, *Carpinus* — *Ostrya* — *Ostryopsis* at one end of the family and *Alnus* — *Betula* at the other. *Corylus* occupies a position off at one side and not clearly to be identified with either of the other groups.

(2) *Carpinus*, *Ostrya*, and *Ostryopsis* form a straight-line sequence.

That is, the change from *Carpinus* to *Ostrya*, carried on still further in the same direction, will reach *Ostryopsis*. The model, of course, gives no hint of the direction of this apparent phylogenetic sequence; whether it is from *Carpinus* to *Ostryopsis*, or *vice versa*.

Betula was the only genus for which the intersectional figures were complete enough to warrant detailed comparison between sections and genera. A model of the sub-sectional relationships in *Betula* on the same scale as the other model is shown in Figure 1. The magnitude of sub-sectional differences in *Betula* is clearly less than that of the differences between *Betula* and its closest relatives. The *Nanae* sub-section, however, as measured by this index shows a divergence from the other three sub-sections greater than that between *Ostrya* and *Carpinus*.

SUMMARY

(1) The qualitative nature of taxonomic units is briefly discussed.

(2) A quantitative method is advanced for dealing with these units, and generic and specific differences in the Betulaceae are compared. It is shown that the latter are much smaller, and that they are approximately equal in average magnitude from genus to genus.

(3) Models are constructed showing on the same scale the comparative divergence between the genera of the Betulaceae and of certain sub-sections in the genus *Betula*.

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THE BIOLOGY OF MILESIAN RUSTS

J. H. FAULL

With plates 84 to 86

As PART of a contribution towards a monograph on *Milesia* I have recently presented an account of the taxonomy and geographical distribution of the species of this genus (2). The paper now offered, the third of a series on the Pucciniastreae, is devoted, except for a short section on economic considerations, to topics on the biology of Milesian rusts. These topics comprise (1) hosts, (2) life history studies, (3) developmental periods, (4) habits of spore production, (5) host restrictions.

HOSTS

Ferns and ferns only serve as hosts for the diploid generation of all known species of rusts belonging to the genus *Milesia*. These are representatives of about sixteen genera scattered among various subfamilies of the one family, the Polypodiaceae. This limitation is an interesting phenomenon the significance of which can only be conjectured because the Polypodiaceae are regarded as the most recent family of homosporous Filicales. The genera and the subfamilies to which they belong are as follows: ACROSTICHEAE - *Elaphoglossum;* ASPIDIEAE - *Dryopteris, Polystichum;* ASPLENIEAE - *Asplenium, Blechnum, Diplazium, Scolopendrium;* DAVALLIEAE - *Nephrolepis, Odontosoria;* POLYPODIEAE - *Drynaria, Polypodium;* PTERIDEAE - *Coniogramme, Cryptogramma, Histiopteris, Pellaea;* WOODSIEAE - *Dennstaedtia.* Lacking from the list are but the two small subfamilies VITTARIEAE and OLEANDREAE.

In addition to the fact that the fern hosts compiled above are all polypodiaceous they are characterized in common by the general habit of "overwintering" some of their fronds in a more or less green condition. Recognition of this feature is important both to the collector and the student of Milesian rusts. This fact is emphasized because associated with it is the postponement beyond the current season, typical of so many species, of the formation of teliospores; they develop with exceptions in the spring on overwintered, affected fronds. Associated also is the production of crops of uredospores (often the most prolific)

in the spring on the overwintered, affected fronds. The latter phenomenon explains how it is that a species of *Milesia* may be perpetuated indefinitely without the necessity of teliospores and a haploid stage; it likewise provides a basis for a reasonable understanding of the world-wide distribution and the course of evolution beyond the range of the one known generic alternate host of this remarkable group of rusts.

Alternate hosts have been more or less satisfactorily determined for ten (nine if *M. fructuosa* is the same as *M. intermedia*) species of *Milesia*, and in every instance they have proved to be species of *Abies*. Heretofore no consistent effort has been made to discover how many species of *Abies* might be susceptible to any one particular species of *Milesia*. But as Klebahn (7) found that *A. alba* and *A. cephalonica*, the only ones he tested, served as hosts for *M. Blechni*, and Kamei (4) found that *A. Mayriana*, *A. firma* and *A. sachalinensis*, the only ones he tested, served as hosts for *M. exigua*, there appeared to be ground for anticipating that host restrictions are not prevalent in firs to anything like the same extent as in ferns. The results of experiments recorded in this paper in which *M. fructuosa* was tested out on a wide range of fir species add confirming evidence to this supposition. In addition to the nine or ten species whose alternate hosts are known there are approximately fifteen species whose teliospores have been described but for which as yet the haploid stage remains to be discovered. All but one of these occur within the range of *Abies;* they include such well-known species as *M. murariae, M. Feurichii, M. Polystichi.* It is almost certain that they, too, pass to *Abies*. Regarding the remainder of the species, those for which uredospores only are known, any from north temperate regions, such as *M. Magnusiana,* doubtless produce teliospores and likely have *Abies* as alternate host. Naturally there is uncertainty regarding the haploid hosts of those species that are restricted to areas beyond the range of *Abies*. As a matter of fact our acquaintance with such species is still so limited that we know of the existence of teliospores in but the one species, *M. australis*. Elsewhere (2) I have advanced the hypothesis that at least some of the Milesian species of the tropics, subtropics and Southern Hemisphere may be imperfect species, evolutions from the diploid phase of perfect species and perpetuated solely by means of uredospores. In any case it is clear that a great deal of fascinating observation and experimentation remains to be done on host relationships of a large proportion of the species of *Milesia*.

LIFE HISTORY STUDIES

The first successful study of the complete life history of any species of *Milesia* was made by Klebahn (7); the species studied was *M. Blechni* (Syd.) Arthur. Professor Klebahn employed as primary inoculum telial material from overwintered fronds of *Blechnum Spicant* (L.) With. collected in the spring of the year. At various dates between May 16 and June 5, 1915, portions of the inoculum were suspended over small potted plants of *Picea Abies* (L.) Karst., *Abies alba* Mill. and *A. cephalonica* Loud.; these were then covered by bell jars and kept covered for as long as six days. *Picea* remained free from infection; but on *Abies* evidences of aecial formation began to appear June 21 on the earlier inoculated plants, and the first mature aecia were observed July 10, or 55 days after the experiment was started. This interval may be taken as an approximately correct measure of the developmental period of the rust on *Abies,* for while it would actually be shorter at least by the time that elapsed between the setting of the inoculum in place and the shedding of the basidiospores, yet this could not have been more than a few days at most because the inoculating material in any instance was not in use for more than six days. All of the experimental plants of both species of *Abies* produced a copious crop of aecia, but on needles of the current season only. Some of the aecial-bearing needles were distributed in Jaap's Fungi selecti exsiccati under number 774a; the remainder were used for the inoculating of ferns of the species *Blechnum Spicant* (L.) With., *Dryopteris spinulosa* (O. F. Müller) Kuntze and *Scolopendrium vulgare* Smith.

The ferns were inoculated at various dates beginning July 20. A marked degree of infection resulted on *Blechnum,* the plants first inoculated showing clear indications of rust along in August; the developmental period in all instances was protracted. No mention was made of any signs of infection on *Dryopteris.* Injuries were observed on *Scolopendrium,* but their cause was not determined; somewhat similar injuries on *Blechnum* were ascribed to the effects of manipulation of the fronds during the course of the experiment. These cultures were supplemented by others in which uredospores from pustules on overwintered fronds of *B. Spicant* were transferred under suitable conditions to new, healthy fronds of the same species; the results were positive. Thus, inoculations made June 21 were followed by the production of uredinia which began to sporulate July 12, indicating a developmental period of three weeks. Summarizing, Klebahn established the outstanding facts that *Abies,* equally true for both species tested, serves as the alternate

host of *Milesia Blechni,* and that this rust is capable of perpetuation from year to year on its fern host alone without the alternation of the aecial stage.

Life history studies of certain other species of *Milesia* have been reported more recently by Faull (*2*) and by Kamei (4, 5, 6); in addition, Dr. Eugène Mayor informs me that he has obtained uredinia of *M. Kriegeriana* (Magnus) Arthur by sowing aeciospores of a white-spored *Peridermium* on fronds of *Dryopteris spinulosa* (O. F. Müller) Kuntze, but his publication has not yet appeared.

To Kamei we owe accounts of determinations of the host interrelationships of *Milesia exigua* Faull (*Milesina vogesiaca* Kamei, not Sydow), *Milesia jezoensis* (Kamei) Faull, *M. Miyabei* (Kamei) Faull

The telial materials of *M. exigua* with which Kamei initiated his studies (4) of that species were collected in the fall from fronds of the current season of *Polystichum Braunii* (Spenner) Fée. They were placed in cotton bags and hung on the shady side of a wall to overwinter. The following spring, at the time the new leaves of *Abies* were unfolding, portions of the fronds carrying teliospores were placed in Petri dishes lined with moist paper and kept there until basidia began to emerge—an interval of two or three days as it proved to be. The pieces so treated were next placed on the foliage of potted firs freshly sprayed with water, and all covered with bell jars for two or three days. After the bell jars were removed the inoculated firs were transferred to a cool place and watered daily. In the course of his experimentation three species of *Abies* were tested, namely, *A. Mayriana* Miyabe & Kudo,[1] *A. sachalinensis* Mast. and *A. firma* Sieb. & Zucc. Infection resulted in all three species and in the new needles only. Spermogonia appeared in from 13 to 20 days following inoculation, and aecia in from 21 to 28 days. Six out of nine tests on *A. Mayriana* were successful, one (spermogonia only) out of three on *A. sachalinensis* and one out of two on *A. firma.* From aecia that formed on *A. Mayriana* and *A. firma* one sowing of aeciospores each was made on fronds of *P. Braunii,* the first on pinnae of a potted plant, the second on detached pinnae in a Petri dish. Uredinia developed within 17 and 13 days respectively. While we might wish that the data were more voluminous we can unreservedly accept Kamei's conclusion that *M. exigua* alternates between *Abies* (three species tested) and *P. Braunii.*

Milesia jezoensis was the next species studied by Kamei (5). Telial

[1]*Abies Mayriana* is often considered a variety of *A. sachalinensis* - *A. sachalinensis* var. *Mayriana* Miyabe & Kudo.

material was collected in the spring on overwintered fronds of *Polypodium vulgare* L. The portions to be employed as inoculum were placed in a moist chamber and left there until basidia could be detected—a period of two or three weeks. Just what the unexpected length of this interval means is not clear, that is, whether the teliospores were immature at the time of collection or that in this species they require a resting period before germination will take place or that the early growth of the basidia is exceptionally slow or that conditions suitable for immediate rapid growth were not provided. As soon as the basidia emerged the inoculum was suspended over the foliage of small, potted trees of *A. Mayriana* on which the new needles had recently expanded, the same technique being employed as for *M. exigua*. Four out of nine tests were successful, and in these spermogonia appeared on needles of the current season only and within about 20 days. For some reason, probably because of poor condition of the firs, no aecia developed and most of the infected needles dropped before the end of the summer. Naturally because of the lack of aeciospores inoculations in the opposite direction, that is, from *Abies* to *Polypodium,* were impossible. While the incompleteness of this experimentation and the paucity of data obtained call for a repetition of the work, yet Kamei's conclusion as to the host connections of *M. jezoensis* may be reasonably accepted as correct.

Kamei has likewise reported (6) partial life history studies of *M. Miyabei* and *M. Dryopteridis,* but his published data on these are particularly meager. For both species the telial materials employed as inocula were collected on overwintered fronds—on *Dryopteris crassirhizoma* Nakai for *M. Miyabei* and on *M. viridescens* (Bak.) Kuntze for *M. Dryopteridis.* Inoculations were made on *Abies Mayriana* and in due course lesions appeared, but on the new needles only. Eventually these bore spermogonia and aecia in the case of *M. Miyabei,* but spermogonia only in the case of *M. Dryopteridis.* For the latter the developmental period up to the production of spermogonia was about 38 days; no time records were given for *M. Miyabei.* Here again, while the results warrant the reasonable conclusion that *A. Mayriana* may carry the haploid stage of *M. Miyabei* and *M. Dryopteridis,* fuller and more complete data are desired.

My own researches have pertained to the species *Milesia intermedia* Faull (probably a condition of *M. fructuosa* Faull in which the uredinia are omitted or if present at all are much reduced), *M. fructuosa* Faull, *M. marginalis* Faull and Watson, and *M. polypodophila* (Bell)

Faull. These were conducted during the summers of 1924-7 at the University of Toronto Field Laboratory of Forest Pathology located on Bear Island, Lake Timagami, Timagami Forest Reserve, Ontario, and during the summer of 1933 at the Arnold Arboretum, Harvard University, Jamaica Plain, Mass. In the former locality all these rusts are readily obtainable in ample quantities on their fern hosts; and their coniferous host, *Abies balsamea* (L.) Mill., abounds. In the latter locality neither the fern hosts nor spontaneous plants of *Abies* occur; the material used as inoculum was collected on ferns in the Berkshire Mountains of western Massachusetts, and the firs inoculated were trees that at one time or another had been planted in the Arboretum.

Studies on each of the species began with the telial stage. At the time the new needles of *Abies* were expanding overwintered fronds bearing teliospores were brought into the laboratory, and, so as to force spore germination, they were placed between folds of wet paper or laid on damp sphagnum moss in large loosely covered cans. Small test pieces were also kept under moist conditions in Petri dishes to afford greater ease of observation. Close watch was kept for the emergence of basidia and the first formation of basidiospores. As soon as basidiospores were freely appearing the material was ready for making inoculations. In setting up an experiment a portion of a frond carrying inoculum was either laid, abaxial surface down, directly on the foliage of a small branch of the host to be inoculated, or it was first prepared for easier handling and greater economy in use by laying it between two strips of galvanized wire netting, separated from the upper strip by a piece of wet absorbent paper. The chosen branch by way of its preparation was sprayed with water from an atomizer and so flexed that its lower face would come in juxtaposition with the basidial-bearing face of the piece of frond. A celluloid cylinder about six inches long by two inches in diameter (E. E. Hubert—Celluloid cylinders for inoculation chambers. Phytopath. 6:447–450. 1916) plugged at one end with wet sphagnum was then slipped over the branch and its adjustment completed by packing its proximal end around the branch in its axis with wet sphagnum. Whenever necessary the branch was propped to keep it as nearly as possible in a horizontal position until the tube was finally removed some days later. The experiment was visited daily as long as the tube was in use, and the sphagnum plugs were kept wet by the addition of water as needed. Similar technique was employed in subsequent inoculations of ferns except that the inoculum consisted of a suspension of spores in water which was sprayed on the fronds.

TABLE 1. *Milesia intermedia*—

from *Dryopteris spinulosa intermedia* to *Abies balsamea*

Date of inoculation	First appearance of lesions	First appearance of spermogonia	First appearance of peridermia	Date harvested	No. of needles infected	No. of needles with peridermia
27. vi.24	14 days	—	36 days	40 days	50	33
27. vi.24	14 "	—	36 "	40 "	100	80
27. vi.24	14 "	—	34 "	45 "	150	140
27. vi.24	14 "	—	34 "	40 "	90	80
28. vi.24	13 "	—	35 "	39 "	32	26
28. vi.24	13 "	—	33 "	39 "	24	21
28. vi.24	12 "	—	33 "	41 "	100	90
28. vi.24	12 "	—	33 "	41 "	90	80
28. vi.24	12 "	—	33 "	39 "	100	80
4.vii.27	14 "	16 days	34 "	43 "	—	2
4.vii.27	13 "	15 "	38 "	43 "	—	4
4.vii.27	13 "	15 "	34 "	43 "	—	8
4.vii.27	19 "	19 "	34 "	43 "	—	5
4.vii.27	19 "	21 "	37 "	43 "	—	5
4.vii.27	13 "	19 "	32 "	43 "	—	13
4.vii.27	13 "	19 "	34 "	43 "	—	15
4.vii.27	—	—	34 "	43 "	—	3
4.vii.27	16 "	19 "	35 "	43 "	—	7
5.vii.27	15 "	20 "	34 "	45 "	—	10
5.vii.27	13 "	18 "	34 "	45 "	—	17
5.vii.27	13 "	20 "	34 "	45 "	—	17
5.vii.27	18 "	20 "	34 "	45 "	—	8
5.vii.27	10 "	20 "	36 "	45 "	—	5
5.vii.27	18 "	18 "	37 "	45 "	—	7
5.vii.27	18 "	20 "	—	—	—	0
6.vii.27	17 "	17 "	33 "	45 "	—	13
6.vii.27	11 "	14 "	33 "	45 "	—	11
6.vii.27	11 "	14 "	33 "	45 "	—	23
6.vii.27	11 "	17 "	36 "	45 "	—	2
6.vii.27	14 "	17 "	33 "	45 "	—	5
6.vii.27	12 "	17 "	33 "	45 "	—	16
Averages	14 "	18 "	34 "			

Average no. of peridermia per needle bearing peridermia—7.
Peridermia ruptured in from 1 to 6 days or an average of about 3 days.
No. of controls examined 74 to 152.
One experiment without infection.
Percentage of needles infected varied from 1 to 33.

All of the experiments were conducted out-of-doors. Two sets of experimental plants were used in the Timagami experiments, one set consisting of well-established potted plants located in a protected "garden" where natural infection was altogether unlikely (in our experience none ever occurred) and under as nearly normal conditions as possible; and a second set consisting of undisturbed plants in a favorable natural hábitat, in localities well removed from occurrences of Milesian rusts. The latter set likewise remained free from natural infections. In the Arnold Arboretum experiments the undisturbed trees scattered about the Arboretum were used; an auxiliary set was not necessary because these trees are entirely free from Milesian rusts and far removed from any possible source of spontaneous infection. Uninoculated branches and uninoculated plants in the immediate neighborhood served as controls. Data on the experiments are assembled in Tables 1-7.

TABLE 2. *Milesia intermedia*—

from *Abies balsamea* to various ferns

Fern inoculated	Date of Inoculation	Date Harvested	Results
Dryopteris spinulosa intermedia	12.viii.24	5.vi.25	III
" " "	16.viii.27	27.vi.28	III
" " "	12.viii.24	5.vi.25	III
" " "	24.viii.24	5.vi.25	III
Dryopteris spinulosa	16.viii.27	30.vi.28	III
" "	12.viii.24	5.vi.25	III
Dryopteris marginalis	16.viii.27	30.vi.28	No infection
" "	19.viii.27	28.vi.28	" "
" "	19.viii.27	28.vi.28	" "
" "	19.viii.27	28.vi.28	" "
" "	20.viii.27	27.vi.28	" "
Dryopteris cristata	16.viii.27	28.vi.28	No infection
Dryopteris fragrans	20.viii.27	29.vi.28	No infection
" "	20.viii.27	29.vi.28	" "
" "	20.viii.27	29.vi.28	" "
" "	20.viii.27	29.vi.28	" "
" "	20.viii.27	29.vi.28	" "
Polystichum acrostichoides	16.viii.27	27.vi.28	No infection
" "	19.viii.27	27.vi.28	" "

The aeciospores used as inoculum were produced in the experiments recorded in Table 1.

TABLE 3. *Milesia marginalis*—

from *Dryopteris marginalis* to *Abies balsamea*

Date of inoculation	First appearance of lesions	First appearance of spermogonia	First appearance of peridermia	Date harvested	No. of needles infected	No. of needles with peridermia
27. vi.24	13 days	—	47 days	53 days	180	160
25. vi.24	21 "	—	51 "	55 "	14	14
25. vi.24	19 "	—	51 "	55 "	25	25
27. vi.24	13 "	—	42 "	53 "	150	130
27. vi.24	13 "	—	42 "	53 "	21	20
27. vi.24	13 "	—	42 "	55 "	400	310
28. vi.24	13 "	—	46 "	54 "	170	130
28. vi.24	13 "	—	46 "	52 "	380	270
28. vi.24	13 "	—	46 "	52 "	250	190
28. vi.24	13 "	—	41 "	52 "	200	170
28. vi.24	13 "	—	41 "	52 "	290	250
28. vi.24	13 "	—	41 "	52 "	190	140
28. vi.24	13 "	—	43 "	54 "	330	260
28. vi.24	13 "	—	41 "	52 "	55	50
28. vi.24	13 "	—	41 "	52 "	260	210
29. vi.27	12 "	18 days	40 "	54 "	—	105
29. vi.27	18 "	18 "	45 "	54 "	—	8
29. vi.27	14 "	19 "	43 "	54 "	—	19
29. vi.27	12 "	18 "	42 "	54 "	—	58
29. vi.27	12 "	18 "	43 "	54 "	—	21
29. vi.27*	12 "	18 "	39 "	54 "	—	106*
29. vi.27	12 "	18 "	39 "	54 "	—	87
29. vi.27	14 "	19 "	40 "	57 "	—	52
29. vi.27	14 "	19 "	42 "	57 "	—	77
29. vi.27	12 "	19 "	42 "	57 "	—	26
29. vi.27	14 "	19 "	42 "	57 "	—	57
29. vi.27	12 "	18 "	42 "	57 "	—	83
29. vi.27	14 "	18 "	45 "	57 "	—	26
29. vi.27	12 "	19 "	45 "	57 "	—	41
30. vi.27	18 "	23 "	42 "	57 "	—	40
30. vi.27	18 "	21 "	44 "	57 "	—	43
30. vi.27	15 "	23 "	42 "	57 "	—	51
5.vii.27	12 "	20 "	39 "	52 "	—	21
5.vii.27	14 "	20 "	45 "	52 "	—	3
5.vii.27	12 "	20 "	45 "	52 "	—	4
5.vii.27	12 "	20 "	40 "	52 "	—	29
5.vii.27	12 "	20 "	41 "	52 "	—	25
5.vii.27	12 "	20 "	41 "	52 "	—	34
Averages	14—"	19+"	43 "			

Material was ready for inoculation one day after collection.
Average no. of peridermia per needle bearing peridermia—7.
Peridermia ruptured in from 1 to 8 days or an average of about 4 days.
No. of controls 54 to 1114.
Four experiments without infection.
Percentage of needles infected varied from 2 to 65, an average of 33%.
Percentage of needles infected when inoculation was at best, an average of 40%.

*Plates 84 and 85 are photographic records of this experiment.

TABLE 4. *Milesia marginalis*—

from *Abies balsamea* to various ferns

Fern inoculated	Date of Inoculation	Date Harvested	Results
Dryopteris marginalis	20.viii.24	22.vi.25	II, III abundant
" "	20.viii.24	5.vi.25	II, III "
" "	24.viii.24	5.vi.25	II, III
" "	22.viii.27	27.vi.28	II, III very abundant
" "	22.viii.27	27.vi.28	II, III abundant
" "	25.viii.27	28.vi.28	II, III abundant
" "	25.viii.27	28.vi.28	II. Frond injured by an animal
" "	26.viii.27	28.vi.28	II, III
" "	26.viii.27	29.vi.28	II, III abundant
Dryopteris cristata	23.viii.24	22.vi.25	No infection
" "	23.viii.24	22.vi.25	" "
" "	23.viii.24	22.vi.25	" "
" "	23.viii.24	22.vi.25	" "
" "	22.viii.27	28.vi.28	" "
" "	25.viii.27	28.vi.28	" "
Dryopteris fragrans	25.viii.27	29.vi.28	No infection
" "	25.viii.27	29.vi.28	" "
" "	27.viii.27	29.vi.28	" "
" "	27.viii.27	29.vi.28	" "
Dryopteris spinulosa	23.viii.24	22.vi.25	No infection
" "	22.viii.27	29.vi.28	" "
" "	22.viii.27	30.vi.28	" "
" "	25.viii.27	27.vi.28	" "
Dryopteris spinulosa intermedia	20.viii.24	22.vi.25	No infection
" " "	20.viii.24	22.vi.25	" "
" " "	22.viii.27	27.vi.28	" "
Polypodium virginianum	25.viii.24	22.vi.28	No infection
" "	25.viii.24	22.vi.28	" "
Polystichum acrostichoides	22.viii.27	27.vi.28	No infection
" "	25.viii.27	27.vi.28	" "
" "	26.viii.27	27.vi.28	" "

The aeciospores used as inoculum were produced in the experiments recorded in Table 3.

TABLE 5. *Milesia polypodophila*—

from *Polypodium virginianum* to *Abies balsamea*

Date of inoculation	First appearance of lesions	First appearance of spermogonia	First appearance of peridermia	Dates of harvest
21.vi.24	Summer of 1926	June, 1927	25.vii.27 (on needles of 1924)	7.viii.28 (needles of 1924-5) (Herb. #8597)
21.vi.24	Summer of 1926	June, 1927	25.vii.27 (on needles of 1924)	25.viii.28(needles of 1923-5) (Herb. #8596)
21.vi.24	Summer of 1926	June, 1927	19.vii.27 (on needles of 1924)	28.vii.27 (Herb. #8380) 12.vii.28 (needles of 1924-5) (Herb. #8598)

The telial material of *M. polypodophila,* on overwintered fronds of *Polypodium virginianum,* was collected June 19, 1924. The fronds were placed at once in a moist chamber. There was an abundance of basidiospores in evidence two days later, and that same day, June 21, fourteen experiments were set up. The inoculated plants were closely examined from time to time during the remainder of the summer, but no signs of infection could be detected. Likewise, during 1925 there were no obvious signs of infection; but some needles were perhaps very slightly paler than others; an examination of a few of these revealed the presence of mycelium. By midsummer of 1926 needles on some of the experiments were more certainly paler and samples of these were found to contain mycelium. During the winter or spring of 1926-7 some of the experimental plants disappeared or were broken. In four of those that remained infection could not be demonstrated in 1927 or subsequently. But in three of them infection was not only evident in 1927, but their inoculated branches bore the first crops of spermogonia and aecia. In every instance the sori were restricted to the needles of 1924, that is, to the needles of the primary infection. Spermogonia appeared first in order and they were followed about a month later by peridermia. From four to eight twigs of the season of 1924 (along with needles of earlier years) had been enclosed in each inoculation tube, and in the case of each of the three successful experiments several of these showed primary infection, but only on needles of 1924.

Final examinations were made in 1928 and in all of the infected twigs referred to above the rust had spread to the needles of 1925, and in two of them to the needles of 1923. Likewise a stimulated growth

TABLE 6. *Milesia polypodophila*—

from *Abies balsamea* to various ferns

(The aeciospores used were from field collections on *Abies balsamea*)

Fern inoculated	Date of inoculation	First observation of uredinia	Date harvested	Results: Stages	Location	Total infections	Pinnae: Total pinnae	Pinnae: with lesions	Herb. No.
Polypodium virginianum	2.viii.24	13.ix.24	13.ix.24	II	Garden	24	—	—	8264
" "	2.viii.24	—	22.vi.25	II	"	—	—	—	—
" "	2.viii.24	13.ix.24	—	II	"	—	—	—	—
" "	2.viii.24	13.ix.24 (lesions only)	13.ix.24	II	"	9	—	—	—
" "	2.viii.24	13.ix.24	13.ix.24	II	"	40	—	—	—
" "	2.viii.24	13.ix.24	13.ix.24	II	"	27	—	—	—
" "	2.viii.24	13.ix.24	13.ix.24	II	"	68	—	—	—
" "	5.viii.24	June 1925	22.vi.25	II	"	—	—	—	8266
" "	5.viii.24	June 1925	22.vi.25	II, III	"	—	—	—	8262(a)
" "	5.viii.24	June 1925	22.vi.25	II, III	"	—	—	—	8262(b)
" "	9.viii.24	June 1925	5.vi.25	II, III	Field	—	13	5	7374(a)
" "	9.viii.24	June 1925	5.vi.25	II	"	—	17	3	7374(b)
" "	9.viii.24	—	5.vi.25	II	"	—	15	6	7374(c)
" "	9.viii.24	—	5.vi.25	II	"	—	21	9	7374(d)
" "	9.viii.24	June 1925	5.vi.25	II, III	"	—	26	13	7374(e)
" "	9.viii.24	15.ix.24 (lesions only)	21.vi.25	II, III	"	41	25	17	7375(a)
" "	9.viii.24	—	21.vi.25	II, III	"	26	23	13	7375(b)
" "	9.viii.24	15.ix.24	15.ix.24	II	"	25	—	—	—
Dryopteris marginalis	4.viii.24	5.vi.25			No infection				
" "	4.viii.24	5.vi.25			" "				
" "	8.viii.24	5.vi.25			" "				
Dryopteris spinulosa intermedia	8.viii.24	5.vi.25			No infection				8260 a
	8.viii.24	5.vi.25			" "				8270 a

The "garden" (pot) cultures showed about 200 primary infections; these bore hundreds of uredinia.

The field cultures showed about an equal number of primary infections; these bore hundreds of uredinia.

The frond under number 7375a showed lesions on 17 out of 25 pinnae; these lesions were rich in teliospores and they carried about 155 uredinia, the number per pinna ranging from 1 to 29.

Out of 21 experiments 3 only showed no infection. Many controls were carried and all remained free from infection.

was obvious, so that one could say with certainty that the loose broom, a characteristic phenomenon in trees affected by *M. polypodophila,* was well started. One of these brooms (Herb. no. 8596), representing the entire result of an experiment, was harvested as a unit. It possesses four primary infection areas. Spermogonia and peridermia occur on the needles of 1923 and 1925 as well as on those of 1924 that still remained (several hundreds in all), and infection has plainly spread to the proximal needles of 1926 in many places.

The percentage of infected needles in a given infected branch area is high—commonly from 90 to 95 per cent. The number of peridermia on individual infected needles of the experiments ranged from one to fourteen, and averaged about seven. Some needles on a successfully inoculated twig remain free from primary infection, but most of them, though not necessarily all, eventually are invaded by mycelium that is perennial in the stem. It should be stated that the spread of the fungus from season to season is by means of mycelium that persists in the stem—mycelium that doubtless originated in primary needle lesions. Needles of all ages are susceptible to infection, but needles of the current season only are susceptible to primary infection. The subsequent course of the mycelium is a growing downward into the contiguous stem, and thence through the cortical tissues of the stem upwards and downwards, the mycelium as it advances sending out hyphal branches into uninfected needles of any age through their bases. Usually affected needles fall off during the winter following the summer in which they bear peridermia. It happens at times, however, that some persist, especially those that produce spermogonia only in that year, and in the following year they produce what is potentially or actually a second crop of peridermia.

The field inoculations were made with aeciospores from a collection made on Timagami Island in Lake Timagami, a part of which collection is incorporated in my herbarium under number 7267. The location chosen was Island 1024, a small island distant from known infections and itself free from infected firs. The island is rocky and in the part chosen for the experiments was largely covered by black spruce (*Picea mariana*), white birch (*Betula papyrifera*), a few scattered white pines (*Pinus Strobus*) and a single sapling of balsam fir (*Abies balsamea*). There was a limited number of *Polypodium virginianum* on the floor of the forest—not more than about 100 fronds all told. Each of these was first carefully examined for signs of rust; no traces of rust were found, and those that were not inoculated remained perfectly free from rust at the end of the experimentation. Experiments were set up

on several each of the fronds of eight plants; one of these plants could later not be located; the selected fronds of the remaining seven became infected as a result of the inoculations made.

TABLE 7. *Milesia fructuosa*—

from *Dryopteris intermedia americana* to various species of *Abies*

Fir inoculated	Date of inoculation	First appearance of peridermia	Date harvested	Remarks
A. amabilis	15.vi.33	None	47 days	Very scanty. Spermogonia only.
A. balsamea	5.vi.33	42 days	47 "	Scanty.
" "	12.vi.33	Non-erumpent	50 "	Scanty.
" "	12.vi.33	None	50 "	Scanty. Spermogonia only.
A. cephalonica	24. v.33	35 days (Non-erumpent)	55 "	Scanty.
A. concolor	24. v.33	35 days	48 "	Occasional.
" "	24. v.33	35 "	55 "	Occasional.
" "	1.vi.33	37 "	37 "	Frequent.
" "	1.vi.33	42 "	47 "	Occasional.
" "	12.vi.33	41 "	44 "	Frequent.
A. Fraseri	1.vi.33	40 "	47 "	Frequent. Distorting.
" "	1.vi.33	36 "	36 "	Frequent. Insect eaten.
" "	1.vi.33	36 "	40 "	Frequent. Distorting.
" "	12.vi.33	39 "	40 "	Frequent. Distorting.
" "	12.vi.33	39 "	44 "	Abundant. Distorting.
A. Fraseri prostrata	6.vi.33	45 "	46 "	Frequent. Distorting.
" " "	6.vi.33	42 "	42 "	Frequent. Distorting.
" " "	13.vi.33	35 "	35 "	Abundant. Distorting.
" " "	13.vi.33	35 "	39 "	Frequent. Distorting.
" " "	14.vi.33	41 "	42 "	Frequent. Distorting.
" " "	14.vi.33	41 "	42 "	Frequent.
A. magnifica	14.vi.33	37 "	38 "	Very abdt. Very distorting.
" "	14.vi.33	36 "	38 "	Very abdt. Very distorting.
" "	14.vi.33	36 "	38 "	Very abdt. Very distorting.
" "	14.vi.33	34 "	34 "	Abdt. Very distorting.
A. nephrolepis	13.vi.33	42 " (Non-erumpent)	49 "	Scarce.
" "	13.vi.33	38 days	43 "	Occasional.

The scope of the investigation, the positive results of which are recorded, was much more extensive than would appear from Table 7. Two hundred and eighty-four inoculations in all were made on twenty-eight species and eight varieties of *Abies*. The species and varieties on which no infection occurred are not enumerated because the experi-

mental conditions were such that negative results were not interpreted as proof of immunity. Temperatures and moisture conditions were unfavorable for the main part throughout the period of the experiment. From May 24, the date of the first inoculations, up through the end of June the weather was abnormally dry and warm, drying winds were above normal, precipitation meager and relative humidity and cloudiness below normal. The rainfall for the last week in May totalled 0.1 inches, for the entire month of June 1.2 inches and for the first half of July 1.4 inches. Moreover, most of the trees inoculated were unavoidably in exposed situations with the result that more or less drying of the needles took place and in many instances there was some sun-scorching of the foliage. The most striking infection was obtained on *Abies magnifica*, and in this instance the trees inoculated were the most protected of all. They are small and are situated in a close copse adjacent to and at the base on the north side of a steep hill covered by a thick stand of hemlocks. The contrast afforded by the scanty, though positive, infection on *Abies balsamea* is particularly worthy of note because this species is the usual haploid host of *M. fructuosa*, and in its natural habitat is often very heavily infected. The trees inoculated in this experiment are small and unprotected on all sides. Measured by these facts it is reasonable to suppose that some at least of the species that remained free from infection would prove susceptible under conditions more favorable to infection.

On the other hand it cannot be assumed that some species of *Abies* may not be immune to *M. fructuosa*, nor that susceptible species differ from one another in their resistance to this rust. As to the latter my experimentation affords grounds for concluding that differences in resistance do exist among the host species. Such is clearly indicated when comparisons are made as between the effects produced by *M. fructuosa* on *Abies balsamea* on the one hand and on *A. Fraseri*, *A. Fraseri prostrata* and *A. magnifica* on the other. *A. balsamea* in nature is often very heavily rusted by *M. fructuosa*, in some instances to the extent that nearly all of the needles of the current season may be rusted, but the infected needles show little evidence of dwarfed growth or distortion. As for the others named and particularly *A. magnifica* checked growth and distortion are pronounced. It is apparent that for *A. magnifica* attacks of *M. fructuosa* might easily be so disastrous as to prove of considerable economic importance in connection with the natural or nursery production of that species.

Since provision had not been made in the experiment for a supply of

plants of the suitable fern host reciprocal inoculations with aeciospores were not made. Admittedly desirable yet under the circumstances such were not necessary to the establishment of the identity of the haploid hosts of *M. fructuosa* because spontaneous infections from this or similar rusts not only did not occur but were practically impossible. It may, therefore, be safely recorded that the following species of *Abies* can serve as hosts for the haploid phase of *M. fructuosa* : *A. amabilis, A. balsamea, A. cephalonica, A. concolor, A. Fraseri, A. Fraseri prostrata, A. magnifica* and *A. nephrolepis.* With respect to geographical distribution of the hosts in their native habitats this list is of added interest because it comprises species of *Abies* from eastern North America, western North America, Europe and Asia.

The reactions of the rust and the various species of *Abies* infected with *M. fructuosa* exhibited some differences. The spermogonia varied somewhat in size and shape; nevertheless they approximated quite closely the spermogonia of the *M. intermedia* form of this species as described (under the erroneous name *Milesina Kriegeriana*) by Hunter (3), and in all instances were clearly distinct from the larger spermogonia of *M. marginalis.* They varied in their distribution on the needles. On all but *Abies magnifica* they were mostly hypophyllous, but in some instances there were occasional epiphyllous spermogonia as well. On *A. magnifica* they were abundantly amphigenous, almost equally distributed on all surfaces. The affected leaves of *A. Fraseri* and *A. Fraseri prostrata* were often more or less deformed; those of *A. magnifica* were much deformed and smaller than normal; those of the other species showed no evident abnormality in size or form. The various morphological phenomena in connection with these infections are being studied in detail by Miss L. M. Hunter.

DEVELOPMENTAL PERIODS

The period of development of the haploid phase on *Abies,* that is, the length of time that elapses between inoculation with basidiospores and the first production of lesions, spermatia and aeciospores respectively, has been partially recorded for eight (seven if *Milesia fructuosa* and *M. intermedia* are the same species) and fully recorded for three of the species of *Milesia* whose complete life histories are known. The data are collated in Table 8.

In the case of each of the species mentioned above the new needles only of *Abies* are liable to infection following inoculation with basidiospores. This cannot be taken to indicate that the older needles are less susceptible; it is more probable that their constant resistance to invasion

TABLE 8

Developmental period of haploid phase of species of *Milesia*

Species of *Milesia*	Species of *Abies*	Period up to first appearance of lesions	Period up to first appearance of spermogonia	Period up to first appearance of peridermia
M. Blechni	*A. alba* *A. cephalonica*	—	36 days. (?)	55 days
M. exigua	*A. Mayriana* *A. firma* *A. sachalinensis*	—	13-20 days, av. (?)	21-28 days, av. (?)
M. jezoensis	*A. Mayriana*	—	20 days	—
M. Dryopteridis	*A. Mayriana*	—	38 days	—
M. intermedia	*A. balsamea*	10-19, av. 14 days	14-21, av. 18 days	32-38, av. 34 days
M. marginalis	*A. balsamea*	12-21, av. 14 days	18-23, av. 19 days	39-51, av. 43 days
M. polypodophila	*A. balsamea*	1-2 years	3 years	3 yrs. 1 mo.
M. fructuosa	*A. amabilis* *A. balsamea* *A. cephalonica* *A. concolor* *A. Fraseri* *A. Fraseri prostrata* *A. magnifica* *A. nephrolepis*	—	—	35-45, av. 38 days

is due to the nature of the barrier afforded by their maturer cuticles and outer epidermal walls. Evidence in support of these conclusions is furnished from plants occupied by the mycelia of *M. polypodophila*. Although primary infection with this species occurs in young needles of the current season only and never in older needles, yet once infection is established hyphae regularly invade healthy needles of the older ages by passing internally from the stem cortex through the tissues of the petioles out into the laminae. Indeed, it would seem that the protoplasmic resistance of such needles is even less than that of needles of the current season, for while the struggle between the latter and the parasite is continued for two years beyond the year of infection before reproductive organs are formed, it is shorter by one year and possibly in some instances by two years in the case of needles secondarily infected. Protoplasmic resistance apparently wanes with age.

The period of development of the diploid phase on ferns, that is, the length of time that elapses between inoculation with aeciospores or uredospores and the first production of lesions, uredospores and teliospores respectively, cannot as yet be expressed with the same exactness

as for the haploid phase. But observations have been made on a considerable number of species and experimentation conducted with a few. As for the latter some statistical information is available for five species, namely, *M. Blechni, M. exigua, M. marginalis, M. intermedia* and *M. polypodophila.*

Klebahn (7) inoculated *Blechnum Spicant* with aeciospores of *M. Blechni* experimentally produced and found that the developmental period following infection was protracted; inoculations made July 20 showed lesions along in August; no statement was made as to when uredinia appeared. Inoculations made with uredospores in June were followed in about three weeks by uredinia. Kamei (4) made two sowings of aeciospores of *M. exigua* experimentally produced on *Polystichum Braunii* and obtained uredinia in 13 and 17 days respectively. Data on the remaining three species are derived from my own experiments.

Dryopteris marginalis inoculated with experimentally produced aeciospores of *M. marginalis,* in pot cultures, on various dates from August 20 to August 22, 1924 and August 22 to August 27, 1927 showed no external evidences of infection up to September 15, the last date of observation for both years. It is regrettable that observations could not have been continued for a month or six weeks longer, because in spite of many frosty nights in the locality of experimentation from the middle of September onward some fairly temperate weather is experienced until towards the end of October, perhaps warm enough at times to permit further growth of the fungus. It should likewise be noted that lesions on *D. marginalis* caused by *M. marginalis* are very slow in discoloring. It is a common experience to find tendrils of white spores standing out from the inconspicuous uredinia on portions of the frond not perceptibly less green than the unaffected parts. Hence it is not improbable that uredinia were formed before the onset of winter—a fact determinable only by very close examination. However this may have been, the first uredinia we observed in our experimental plants were in May of the following springs. Teliospores developed about one month thereafter. No inoculations were made with uredospores, but I have concluded that the developmental period is much prolonged following natural inoculation on new fronds with uredospores in the spring from uredinia on overwintered fronds. Throughout the summer there is no sign of the rust and not until fall are lesions and uredinia evident. I have never found uredinia on fronds of the current season earlier than September, and even then rather sparsely. The abundant crop is on

overwintered fronds the following spring. The uredospores then begin to emerge in snowy tendrils soon after the fronds are exposed, even before the last traces of snow disappear. The teliospores do not develop until about a month later, that is, until about the time the buds of *Abies* are swelling and opening.

Inoculation experiments with experimentally produced aeciospores of *M. intermedia* from *Abies balsamea* were conducted on *D. spinulosa* and *D. spinulosa intermedia*—all in pot cultures. Inoculations were made August 12 to 14, 1924 and August 16, 1927. Neither lesions nor uredinia were observed up to September 15, the last date of observation for both years. Here again, just as with *M. marginalis*, it is possible that there was further development before winter set in. If so lesions probably became evident, for on both hosts mentioned lesions in nature are in evidence during the fall. It was likewise not known at that time that the teliospores of *M. intermedia* may sometimes develop in the fall on fronds of the current season. All that can be said further is that uredinia did not form at any time on our experimental plants and that teliospores were not located until June of the following springs. All these phenomena were typical of natural occurrences for the same periods.

Coming to *M. polypodophila* a difference in the story is presented. Inoculations were made with aeciospores from field collections on both potted plants of *Polypodium virginianum* in our garden and on undisturbed plants in the forest. These were made at various dates between August 2 and August 9, 1924. In almost every instance lesions were evident by the middle of September, and many of these bore uredinia by September 13. The elapsed period culminating in production of uredospores ranged from 37 to 42 days. In no instance, however, did teliospores develop on the infected fronds until June of the following spring. These phenomena coincide with observations on natural infections whether in infections following aeciospores or uredospores. Uredinia in such cases may occur as early as August, but I have never found teliospores on fronds of the current season. They appear first on overwintered fronds at about the time the buds of *Abies* are swelling and breaking. The data recorded above are summarized and embodied in Table 9.

Any information on the developmental period of the diploid phase of species of *Milesia* on ferns derived from labels that accompany herbarium specimens can at best be little more than suggestive. Such records do indicate, however, that there are considerable differences

TABLE 9

Developmental period of diploid phase of species of *Milesia*

Species of *Milesia*	Host	Inoculum used and results
M. Blechni	*Blechnum Spicant*	Aeciospores—protracted development. Uredospores — uredinia in 3 weeks.
M. exigua	*Polystichum Braunii*	Aeciospores—uredinia in 13 and 17 days.
M. marginalis	*Dryopteris marginalis*	Aeciospores—no external signs of lesions at end of 24 days; some uredinia may have formed in late fall, but seen first in spring of following year. —teliospores developed in spring of following year.
M. intermedia	*Dryopteris spinulosa* *D. spinulosa intermedia*	Aeciospores—no external signs of lesions at end of 34 days; no uredinia formed at any time. —teliospores developed in spring of following year.
M. polypodophila	*Polypodium virginianum*	Aeciospores—uredinia in 37 to 42 days. —teliospores developed in spring of following year.

according to the species. The most striking instance of prompt development is afforded by *M. murariae* on *Asplenium Ruta-muraria* in collections from Switzerland; specimens collected as early as June 12 carry a prolific crop of uredinia on the new fronds. This is in striking contrast to *M. fructuosa* on *Dryopteris spinulosa intermedia* in which the earliest production of uredinia occurs in the fall. As intermediates between these two there is a range from early June to late August as illustrated by the series *M. Feurichii, M. Blechni, M. dilatata, M. Scolopendrii, M. carpatica, M. vogesiaca, M. fructuosa* (on *D. spinulosa americana*), *M. Polypodii, M. Polystichi* and *M. Kriegeriana.*

HABITS OF SPORE PRODUCTION

(a) SPERMATIA

Some observations were made on the production of spermatia and their period of discharge in connection with my field studies of *M. intermedia, M. marginalis* and *M. polypodophila.* As might be inferred from the relatively large size of their spermogonia and the ample protection afforded them by the host tissues spermatia are produced profusely and their discharge is continued over many days. Examinations of these phenomena were made daily with respect to *M. polypodophila.* In this species as in the others there is an outpouring of the spermatia in liquid suspension, but in *M. polypodophila* it is especially copious. When

the weather is humid the liquid spreads over the entire lower surfaces of the needles on which they are borne, and at times it fairly drips from the needles. It is somewhat sticky and sweetish, but no odor was detected. Discharge was found to continue for about thirty days.

The following excerpts from my field notes (4843) in the Timagami Forest Reserve, Ontario, under date June 9, 1924, embodying observations on the spermogonia of *M. polypodophila* and their habit of discharge, present a graphic picture of the spermogonia of *M. polypodophila* and their behavior. "The affected leaves are now moist on the lower surface, films and droplets—due to the active exudation of spermatia and a colorless fluid. A needle (leaf) pressed against a clean dry glass slide leaves an almost continuous smear of spores and liquid. The spores are hyaline, one-celled, cylindrical to ellipsoidal, and occasionally almost rod-shaped. They measure 2.5-3.2 x 3.5-7 μ. The majority are about 3 x 5 μ. The needles along stretches of the axis of the branch (1) continuous with those that bore peridermia last year, (2) or that carried peridermia-bearing needles last year (now fallen off) show many inactive spermogonia. These are greenish-yellow in color with a blackish dot in the center. On the same needles are new spermogonia interspersed with the old ones, on restricted portions of the needles (usually towards their tips) on which areas there are few or no old ones. The new spermogonia are actively discharging; they are slightly discolored (bluish with yellowish tinge) and the central point is moist and not discolored. The affected needles along these stretches of the stem axis are distinctly paler (slightly yellowed) than normal leaves. Contiguous with these stretches are lengths of the axis on which the needles carry new spermogonia only. These needles are scarcely paler than normal needles on their lower surfaces and not paler on their upper. The spermogonia are commonly scattered along the full length of the needles, but are sometimes restricted to limited portions from the bases outward and not extending all the way to the tips. This is especially true of the needles farthest removed from the affected areas of last year. Nearly all of the needles along a given affected stem axis are infected. The length of an axis affected in a given season bears no relation to a season's growth.

"The number of spermogonia on a needle varies from ten to twenty and they are spaced in lineal rows, one on each side of the midrib. Frequently there may be a stoma more or less eccentrically located on the epidermis that covers a spermogonium. This opens wide, the opening with a jagged line of broken cuticle, and through the opening the spermatia are being discharged."

(b) Aeciospores

The peridermia of these species with their first apparently mature aeciospores appear in from two weeks to a month after the spermogonia begin their spermatial discharge—an average of 16 days for *M. intermedia*, 24 days for *M. marginalis* and about 30 days for *M. polypodophila*. The peridermia rupture at their apices and discharge of the aeciospores begins. Rupture is delayed for a few days, however, the length of the interval apparently depending to some extent on weather conditions, being shorter when the weather is rainy or when there are heavy dews. The intervals were found to vary from less than a full day to six days for *M. intermedia*, with an average of three days, and from one to eight days for *M. marginalis*, with an average of four days. The discharge of aeciospores is protracted over a comparatively long period of time. For example it has been frequently noted that peridermia of *M. intermedia* formed soon after the middle of August were shedding spores until towards the end of September.

(c) Uredospores

The habits of uredospore production characteristic of Milesian rusts exhibit considerable diversity, as was discovered from comparative observations on various species. An interpretation of the factors underlying the differences manifested is complex, but much of interest could probably be elucidated by experiment. The factors involved are to be sought for in the innate characters of the individual species, the degree of compatibility as between host and parasite, the influence of the host and the influences of moisture and temperature.

Uredospore production from the same frond is usually active over a long period of time, interrupted only during periods of low temperature or drought. To what extent this applies to individual uredinia is uncertain. In some species, as in *M. Blechni* and several tropical forms, it seems to be relatively short as indicated by the circumstance that often many uredinia at the time of gathering are completely empty—sometimes to such an extent that few or no spores can be found in a collection. In others spores can be found in practically all uredinia regardless of age, as in most of the temperate zone species. The length of the time during which uredospores are produced on a frond naturally depends on the promptness with which uredinia are formed on new fronds and the longevity of these fronds after being overwintered. Striking examples of long sporulating periods are afforded by such species as *M. murariae* and *M. polypodophila*. In the former the new

fronds become infected in spring and sporulation is at once abundant; the same fronds are still producing spores copiously a year later side by side with heavily infested new fronds. Sporulation does not begin as early in *M. polypodophila*, but it is active from midsummer onward and continues throughout all of the subsequent year even late into the fall. A remarkable example of suspension of spore production due to drought is found in *M. laeviuscula* on *Polypodium californicum*. Infection must take place in the spring; but during the drought period, which in parts of California where the rust occurs may extend over several months, the fronds and the rust they carry are inactive. With the coming of the winter rains fronds and rust are revived and sporulation begins, to be continued well on into the following spring. An example of a *Milesia* in which the sporulating period is comparatively short is afforded by *M. marginalis*. Uredinia of this species according to my observations do not form until fall on fronds of the current season, and spore production that season is quite limited. The heavy spore discharge takes place the spring following, but it is rarely continued beyond June, and in dry springs the old fronds may die even before there has been normal time for teliospore formation.

Of all species of *Milesia* I have found none quite so perplexing with respect to uredospore production as *M. intermedia*. Widely distributed throughout the range of *Abies balsamea*, a common species the frequency of which is made possible by the almost constant presence everywhere of its fern hosts in coniferous or mixed forests, it seems to have wholly escaped the notice of collectors because of its common habit of omitting uredinia. My finding of *M. intermedia* resulted from a deliberate search for teliospores on *Dryopteris spinulosa intermedia* after having discovered those of *M. marginalis* on *D. marginalis*. Once having found the teliospores the abundance of this rust soon became evident. Yet several years elapsed, though constantly watching for them, before its uredospores were encountered. The uredinia as I first found them were scattered, very small, immersed, very inconspicuous and their spore output was scanty. Collections made previously were again painstakingly examined for uredinia but with negative results. Thus far my collecting had been done in the eastern Provinces of Canada and the two most northeasterly States of the United States. In 1932, however, in the course of collecting trips in the more southerly range of *Abies balsamea* in western Massachusetts and Vermont, I found a rust on varieties of *D. spinulosa*, easily manifest because of the abundance of its closely-studded, conspicuous, though small, pustular ure-

dinia and abundant discharge of white uredospores. The latter so closely resembled those which I had hitherto found so scantily on *D. spinulosa intermedia* as to be practically indistinguishable. Because of the differences in uredinia and in the habits of uredospore production, the rust with abundant uredinia was described under the name *M. fructuosa* and the other under the name *M. intermedia*. Regardless of whether or not both names will stand, a useful purpose has been served in calling attention to a rust that otherwise might be passed over because of a condition so often characterized by the entire omission of uredinia.

For the purpose of obtaining fuller knowledge of *M. fructuosa* and *M. intermedia* I made a special collecting trip to Timagami in northern Ontaria, the Green Mountains of Vermont, the Berkshires of Massachusetts and the Adirondacks of New York in the neighborhood of Lake Placid during the middle and latter part of October, 1932. The visits were made at a time when presumably there would be no further growth of the rusts that year. Timagami and the higher elevations of Whiteface Mountain in the Adirondacks were already partly under snow, and all of the localities visited had already experienced killing frosts. The results warranted the efforts made by the extension of our knowledge of distribution, host records, the existence of intergradations of the two "species" and a fuller acquaintance with the habits of teliospore production in *M. intermedia*. To give as complete a picture as possible as a basis for conclusions as to the identity of these species and as a help towards needed further life history experimentation a list of all of my materials of *M. fructuosa* and *M. intermedia* with herbarium numbers and pertinent data is recorded in Table 10.

With these data before us the question arises as to why Milesian uredinia on *Dryopteris spinulosa* and *D. spinulosa intermedia* were not found in Timagami during the years 1924-7, years during which Milesian rusts were being assiduously studied there. I think the correct reply is that if present at all they were rare. The collecting grounds in Timagami were well-defined and were visited often each year. One of these, a small area covered by low-growing *Abies* and interspersed clumps of *Dryopteris spinulosa* and *D. spinulosa intermedia* through the midst of which a trail led was traversed by myself and assistants many times each season. This particular area was one of the best localities for *M. intermedia* both on *Abies* and the ferns, and I repeatedly examined the fronds in search of uredinia; not once were any found. On revisiting the same spot in October, 1932 I found them

TABLE 10

I. *Milesia fructuosa* (continued)

A. On *Dryopteris spinulosa* (O. F. Müller) Kuntze

No.	Place	Date	Stages	Age of fronds
10,853	Timagami, Ont.	Oct. 10, 1932	II, III	Current season
10,852a	" "	Oct. 11, 1932	II, III	" "
10,847	" "	Oct. 14, 1932	II, III	" "
10,854	" "	Oct. 14, 1932	II, III	" "
10,859	" "	Oct. 14, 1932	II, III	" "

B. On *Dryopteris spinulosa americana* (Fisch.) Fernald

No.	Place	Date	Stages	Age of fronds
10,668	Mt. Greylock, Mass.	July 14, 1932	II, III	Overwintered (dead)
10,760	" " "	Aug. 7, 1932	II, III	Current season
10,761	" " "	Aug. 7, 1932	II, III	" "
10,761b	" " "	Aug. 7, 1932	II, III	" "
10,883	" " "	Oct. 22, 1932	II, III	" "
10,887*	" " "	Oct. 22, 1932	II, III	" "
10,771	Sherburne Pass, Vt.	Aug. 10, 1932	II, III	" "
10,768*	Whiteface Mt., N. Y.	Aug. 9, 1932	II (rare) III (empty at this date)	Overwintered
10,876*	Whiteface Mt., N. Y. (lowest margin of range of fern)	Oct. 24, 1932	II, III	Current season
10,877*	Whiteface Mt., N. Y. (a protected, sunny exposure, higher up)	Oct. 24, 1932	II (rare) III (abdt.)	" "

C. On *Dryopteris spinulosa fructuosa* (Gilbert) Trudell

No.	Place	Date	Stages	Age of fronds
10,626	Mt. Greylock, Mass.	June 17, 1932	II, III	Overwintered
10,627	" " "	June 17, 1932	II, III	"
10,628	" " "	June 17, 1932	II, III	"
10,764	" " "	Aug. 6, 1932	II	Current season
10,885	" " "	Oct. 22, 1932	II, III	" "
10,886	" " "	Oct. 22, 1932	II, III	" "
10,629	Searsburg, Vermont	June 17, 1932	II, III	Overwintered
10,665	Mt. Mansfield, Vt.	July 15, 1932	II, III	"
10,669	" " "	July 15, 1932	II, III	"

D. On *Dryopteris spinulosa intermedia* (Muhl.) Underw.

No.	Place	Date	Stages	Age of fronds
10,847a	Timagami, Ont.	Oct. 14, 1932	II, III	Current season
10,848	" "	Oct. 14, 1932	II, III	" "
10,851	" "	Oct. 12, 1932	II, III	" "
10,852	" "	Oct. 11, 1932	II, III	" "
10,854a	" "	Oct. 14, 1932	II, III	" "
10,855	" "	Oct. 14, 1932	II, III	" "
10,892	Becket, Mass.	Oct. 21, 1932	II, III	" "
10,888	Sherburne Pass, Vt.	Oct. 22, 1932	II, III	" "
10,889	" " "	Oct. 22, 1932	II, III	" "
10,893	" " "	Oct. 22, 1932	II, III	" "

*Number 10,876 is from the lower margin of range of host. Number 10,877 is from an open sunny exposure higher up and within the main range of the host and everywhere surrounded by "*M. intermedia*." In Numbers 10,768 and 10,877 the II stage is rare.

II. *Milesia intermedia*

A. On *Dryopteris spinulosa* (O. F. Müller) Kuntze

No.	Place	Date	Stages	Age of fronds
8,272	Timagami, Ont.	June 5, 1925	III	Overwintered (Cultures in which experimentally produced aeciospores on *Abies balsamea* of *M. intermedia* originating on *D. spinulosa intermedia* were used.)
9,850c	" "	June 30, 1928	III	Overwintered (Cultures, ditto.)
10,915	Gaspé Co., Que.	Sept. 8, 1928	III	Current season

B. On *Dryopteris spinulosa americana* (Fisch.) Fernald

No.	Place	Date	Stages	Age of fronds
10,871*	Whiteface Mt., N. Y.	Oct. 24, 1932	III	Current season
10,875*	" " "	Oct. 24, 1932	III	" "
10,878*	" " "	Oct. 24, 1932	III	" "

C. On *Dryopteris spinulosa intermedia* (Muhl.) Underw.

No.	Place	Date	Stages	Age of fronds
4,871	Timagami, Ont.	June 12, 1924	III	Overwintered
7,371	" "	June 16, 1924	III	"
7,373	" "	June 18, 1924	III	"
8,267	" "	June 5, 1925	III	" (Cultures ditto as under 8272)
8,260	" "	June 5, 1925	III	" "
8,270	" "	June 5, 1925	III	" "
9,850d	" "	June 27, 1928	III	" "
9,924	Mt. Washington, N. H.	July 5, 1931	II*, III	Overwintered
10,670	Becket, Mass.	July 12, 1932	II*, III	"
10,664	Mt. Mansfield, Vt.	July 15, 1932	II*, III	"
10,800	Sherburne Pass, Vt.	Aug. 11, 1932	III	" (fronds dead)
10,880	Lake Placid, N. Y.	Oct. 23, 1932	**	Current season
10,881	Wilmington Notch, N. Y.	Oct. 23, 1932	**	" "
***				

*Prevalent throughout the main range of host and very abundant.

**Mostly just sporeless lesions; a few spores of stages II and III in a few of the oldest lesions found after careful searching, in such cases making decision difficult as to whether the rust should be called *M. fructuosa* or *M. intermedia*.

***Affected fronds of current season found in Maine, Quebec and Nova Scotia bore sporeless lesions only.

abundantly and on practically every affected frond. A few hundred yards farther on, in a narrow swampy valley just on the other side of an intervening hill is the place where the type material of *M. intermedia* was collected. Many hours were spent there springs and falls of 1924-7 in intensive, undivided search of uredinia; none were ever found. Yet in October 1932, though snow had to be kicked away to locate the ferns, several fronds bearing uredinia were uncovered. A

subsequent re-examination of my earlier collections (all on overwintered fronds) made from that particular area confirmed my recorded observations that though teliospores were abundant there were no uredinia. Half a mile eastward is still another locality where, except for a single frond bearing uredinia of the *M. fructuosa* type found in 1926 or 1927 (subsequently lost), nothing but non-uredinial *M. intermedia* had been seen. There, in October 1932 almost every affected frond both of *D. spinulosa* and *D. spinulosa intermedia* bore quantities of the uredinia of *M. fructuosa.*

With the contrasting situation in Timagami, in 1924-7 as compared with the situation in 1932, it is illuminating to refer to the contrasting situations that existed on Mt. Greylock, Mass. and Whiteface Mt., N. Y. in the season of 1932. In the former locality, that is, on Mt. Greylock, spring came earlier, rust developed on *Abies* earlier and fall was later. A rust of the *M. fructuosa* type abounded there from early August onward on fronds of varieties of *D. spinulosa* of the current season, while the *M. intermedia* type was absent. On Whiteface Mt. rust abounded on *D. spinulosa americana* and except in the lower reaches and in sunny exposures farther up the mountain uredinia did not occur. Even where uredinia did occur they formed very late in the season and quite scantily. The trail up Whiteface Mt. from Wilmington (northern side of mountain) traverses a mile or more of terrain covered with *D. spinulosa americana;* the fronds of an enormous number of them in the fall of 1932 were laden with teliospores and without uredinia except as just indicated. In other words the condition of the rust was typical of *M. intermedia.*

A similar parallel existed in 1932 as between Wilmington Notch, N. Y. and Sherburne Pass, Vt. with reference to the rust on *D. spinulosa intermedia.* In Wilmington Notch, for the main part sporeless lesions were present; the fronds entered the winter in the same condition I have so often found to prevail in northern Ontario, Quebec, Nova Scotia and the White Mountains of New Hampshire. At Sherburne Pass, on the other hand, there was an abundance of both pustular uredinia and telia, though they developed later in the season than on *D. spinulosa americana* from the same locality.

One of two explanations of these phenomena is probably correct. Either both *M. fructuosa* and *M. intermedia* occur on *D. spinulosa, D. spinulosa americana* and *D. spinulosa intermedia,* varying in relative frequency periodically and locally, or *M. fructuosa* and *M. intermedia* are one and the same species, the production of uredinia potentially

being always possible but actually existent under certain conditions only. From the assembled data even though direct demonstration is lacking, I incline to the latter view.

It might be urged that a compelling argument in favor of regarding *M. intermedia* as a distinct species is the record of *no uredinia* in the six successful cultures recorded above (Table 2). But it is to be borne in mind that since the experiments were conducted out-of-doors the results would have been expected to coincide (as they did) with the occurrences on naturally infected plants in the same territory. Frankly, I suspect that *M. intermedia* is a condition of *M. fructuosa,* a condition characterized by an omission or reduction of uredinia according to environmental influences. This problem and that of biological strains and host preferences afford interesting topics yet to be conclusively investigated.

(d) Teliospores

The first discovery of teliospores of a *Milesia* was made by Magnus (8) in specimens of *Dryopteris spinulosa* affected with *M. Kriegeriana.* They were found on fronds of the current season and it has been fully established that this is the typical habit for that species. Extended acquaintance with other species, however, has revealed the fact that for most of them the teliospores, if known, develop on affected over-wintered fronds only. My discovery of this phenomenon resulted from persistent search for teliospores in an ample collection made in early spring of fronds of *Dryopteris marginalis* rich in uredinia-bearing lesions. A prompt examination for teliospores proved fruitless, but that outcome was not regarded as final because under the belief that these spores are rare I thought they might possibly have been overlooked. Hence as the collection was a large one and only a part of it had been overhauled the fronds were placed in a moist chamber to be kept fresh until the search could be completed. About three weeks elapsed before opportunity was afforded to continue the examination; at once, to my astonishment, I found the lesions throughout crowded with teliospores. Immediate reference to plants in the forest revealed that in them also teliosporic production had taken place. The missing clue to the time of occurrence of the III-stage which subsequent observations have shown to be so prevalent in *Milesia* was uncovered. As the periods of teliospore occurrence for the various species have already been published (2) there is no necessity for listing them here.

A point of interest relevant to those species in which teliospores are

formed on fronds of the current season is the question as to when the teliospores are capable of germination. According to Magnus' account of *M. Kriegeriana* the inference is that the teliospores of that species are immediately germinable. Magnus did not state, however, whether or not germination occurs in the fall under natural conditions, nor did he comment on its relative frequency. Obviously if germination does take place abundantly in the fall such a habit would be wasteful because the needles of *Abies* are not susceptible to infection at that season. Dietel (1) in a later communication recounted that he found the teliospores of *M. Kriegeriana* still ungerminated in the early spring on overwintered fronds bearing them, and I have observed the same phenomenon in suitable specimens of that species which have come to my hand. The nearest parallel to Magnus' observation was my finding in early spring before the new needles of *Abies* unfolded quantities of teliospores with empty cells and open germ pores through which basidia had evidently grown in the case of *M. fructuosa* on *D. spinulosa americana* and *D. spinulosa fructuosa*. Under the circumstances it was impossible to know whether germination had taken place the preceding fall or on exceptionally warm days after the snow cover had melted off in the first blush of spring. That the latter is the more likely interpretation is supported by my recent attempts to germinate the teliospores of this species. Materials were collected in October 1932 from the same hosts and in the same locality, teliospores that must have formed sometime between the middle of August and early October. They showed no signs of germination at the time of collection and all attempts to induce germination in the laboratory have ended in failure up to the time of writing (end of December 1932). It is, therefore, reasonable to conclude that as for *M. fructuosa* its teliospores overwinter in a dormant condition and that germination normally first takes place the following spring at about the time the new needles of *Abies* have just expanded.

In conclusion some comments should be offered with respect to the habit of teliospore formation in the species "*M. intermedia*." From the time of my first finding the species I have observed again and again that sporeless lesions in the fall on fronds of the current season was the prevailing phenomenon, while teliospore-bearing lesions was the prevailing condition on the overwintered fronds the following spring in the same localities. These experiences led me to suppose that the teliospores of this species were formed on overwintered fronds only, but recent observations have revealed the fact that they can also be formed

in the fall on fronds of the current season. On examining a collection of supposedly rusted fronds of *D. spinulosa* made in September 1928 in Gaspé, Que., a collection that had been set aside because the lesions bore no uredinia and presumably no teliospores at that season (Faull, no. 10,915), I found that while some of the lesions were sporeless others already contained teliospores of *M. intermedia*. Similar findings came to light in specimens of rusted *D. spinulosa intermedia* made in October 1932 at Lake Placid, N. Y. and Wilmington Notch, N. Y. My conclusion is that the teliospores of *M. intermedia* do form on the fronds of the current season as well as on affected overwintered fronds depending on the earliness of infection and the nature of the environmental conditions.

HOST RESTRICTIONS

All that is known of host restrictions of various species of *Milesia* has already been referred to or indicated elsewhere in this paper so that a brief recapitulation will suffice. The sole data prior to those presented in this paper on the restrictions of the O-I phase have been contributed by Klebahn and Kamei. Klebahn (7) found that *M. Blechni* would not infect *Picea Abies*, but that the two species of *Abies* he tested served equally as hosts. Kamei (4) found that three species of *Abies* tested were susceptible to *M. exigua*. This paper records a wide range of species of *Abies* susceptible to *M. fructuosa* (Table 7).

With reference to fern hosts Klebahn (7) tested *M. Blechni* on *Blechnum Spicant, Dryopteris spinulosa* and *Scolopendrium vulgare* and found that the first-named alone gave positive results. In my own experimentation the three species *M. intermedia, M. marginalis* and *M. polypodophila* were tried out on several fern species the inoculations being made with aeciospores in each instance. Aeciospores of *M. intermedia* were sown on *Dryopteris spinulosa, D. spinulosa intermedia, D. marginalis, D. cristata, D. fragrans* and *Polystichum acrostichoides*. Infection occurred on the first two, but there was no infection on any of the others (Table 2). Aeciospores of *M. marginalis* were sown on *Dryopteris marginalis, D. cristata, D. fragrans, D. spinulosa, D. spinulosa intermedia, Polypodium virginianum* and *Polystichum acrostichoides*. Infection resulted on *D. marginalis* only (Table 4). Aeciospores of *M. polypodophila* were sown on *Polypodium virginianum, Dryopteris marginalis* and *D. spinulosa intermedia* but infection occurred on *P. virginianum* only (Table 6). It may, therefore, be concluded that the diploid phase of these species is closely host restricted. The data assembled from collections of other species indicate like close

host restrictions. It is true there are a few species like *M. vogesiaca* and *M. exigua* in which several species of ferns are found to be susceptible, but always they are of the same genus. Even here it remains to be determined to what extent biological strains more closely restricted still may exist. The one case in which a *Milesia* may infect ferns of more than one genus is that of *M. nervisequa,* a species the exact generic status of which will be open to question until we know for certain whether or not its spores are white in the fresh condition; but to whatever genus it properly belongs its biological entities will remain unknown until comparative inoculations have been made.

ECONOMIC CONSIDERATIONS

So far as I am aware there are no statistical records extant of the amount of losses to firs or ferns caused by species of *Milesia.* As for ferns the economic damage, in America at least, is probably not of much consequence. Whatever injuries there might be would most concern the owners of properties in summer resort regions where native ferns are so universally grown as outdoor ornamentals. According to my observations the damages from Milesian rusts do not compare with the often distressing injuries caused by species of *Uredinopsis.*

As for *Abies* it is conceivable, judging from what I have seen in the forest, and from what I have seen of the severe effects on the foliage of *A. magnifica* in culture experiments (see Table 7 above), that appreciable injury might result in young plantations where infected ferns are in the immediate neighborhood. Certainly it is true that Milesian rusts do affect natural reproduction to a varying extent. The most important species in this connection covering the range of *Abies balsamea* in eastern America, as deduced from my own more or less casual observations on the subject, are *M. polypodophila* and *M. fructuosa* (including *M. intermedia*).

The former induces a broomy growth of firs, involving practically the entire plant if the attack is made when the tree is young, as is usually the case. The resulting growth is unsightly and worthless. Moreover, in such areas not only is the prospective timber value of the firs spoiled but also none of those badly affected ever produce crops of seeds. Of course, such effects are possible only where *Polypodium* is abundant as part of the under-cover.

Undoubtedly *M. fructuosa* (including *M. intermedia*) is of much wider significance in relation to the natural reproduction of the balsam fir, partly because of its wholesale destruction of new needles and because of the general prevalence of its fern hosts. Seedlings on the forest

floor are either killed outright where infection is heavy or greatly retarded in getting a start. Older plants, up to four or five feet in height, sometimes suffer from the loss of an appreciable part of their foliage of the current season. Indeed I have seen areas in eastern America where *Dryopteris spinulosa* or its varieties abounded, in which rust injury almost certainly played a part in reducing the balsam fir as a constituent of the forest stands or in preventing it from becoming as fully established as it otherwise would. This feature in the competitive struggle for existence applies all the more to firs in the southerly limits of their range, that is in regions where ferns most abound and where the firs are subjected to a greater struggle against unfavoring climatic conditions. Reduced in numbers and checked in growth the firs become outgrown and overgrown by other species. It is probably true that such checks to fir reproduction in many of these instances would be considered desirable from the standpoint of forest values. But, however that may be, the fact remains that whenever intensive studies are being conducted for the purpose of quantitatively forecasting forest successions fern rusts as influencing factors should not be disregarded. Plate 86 illustrates the disastrous effect of a fern rust (*Milesia intermedia*) on seedlings of balsam fir growing under natural conditions. The forester should bear in mind the principle that firs and ferns of certain kinds are incompatible neighbors where fern rusts are strongly entrenched.

ACKNOWLEDGMENTS

For assistance in making the inoculation experiments recorded in this paper I am indebted to Messrs. W. R. Watson, G. D. Darker, E. H. Bensley, I H. Crowell and Miss L. M. Hunter. I wish particularly to acknowledge the devoted efforts of Mr. Watson throughout two summers of fruitful field work.

SUMMARY

1. Milesian rusts are now known in nature (including a few yet unpublished) to occur on species of about sixteen genera of ferns—all of the family Polypodiaceae—distributed among the polypodiaceous subfamilies Acrosticheae, Aspidieae, Asplenieae, Davallieae, Polypodieae, Pterideae and Woodsieae. They are also known either in nature or cultures on eleven species and one variety of *Abies*, namely, *A. alba, A. amabilis, A. balsamea, A. cephalonica, A. concolor, A. firma, A. Fraseri, A. Fraseri prostrata, A. magnifica, A. Mayriana, A. nephrolepis* and *A. sachalinensis*.

2. Hosts of both the haploid and diploid stages in the life histories

are now known for ten species of *Milesia* (nine if *M. fructuosa* and *M. intermedia* are identical), namely, *M. Blechni, M. Dryopteridis, M. fructuosa, M. exigua, M. intermedia, M. jezoensis, M. Kriegeriana* (Mayor, unpublished), *M. marginalis, M. Miyabei* and *M. polypodophila.* This paper records the data of life history studies on *M. fructuosa, M. intermedia, M. marginalis* and *M. polypodophila.*

3. The developmental period of the haploid phase (the phase on *Abies*) of Milesian species varies widely and is approximately constant according to the species. The period up to the first appearance of lesions ranges according to the species from 10 days to 2 years, up to the first appearance of spermogonia from 13 days to 3 years and up to the first appearance of peridermia from 21 days to 3 years 1 month (Table 8). The developmental period of the diploid phase (the phase on ferns) does not show such great differences, but it too varies widely according to species (Table 9).

4. Spermatial discharge is relatively abundant and long continued. The most striking instance is that of *M. polypodophila* for which species it may continue for a month, the spermatial fluid at times fairly dripping from the needles.

Aeciospores make their appearance in from two weeks to a month following the first discharge of spermatia. The period under normal conditions averages about 16 days for *M. intermedia,* 24 days for *M. marginalis* and 30 days for *M. polypodophila.* The discharge of aeciospores may continue over several weeks.

Uredospore production from the same frond is usually active over a long period of time, but there are striking exceptions. Perhaps the most remarkable instance of longevity is afforded by *M. polypodophila*—discharge is known to begin in midsummer and to continue until late in the fall of the subsequent year.

5. Significant variations have been observed in *M. intermedia* as originally defined with respect to the time of formation of teliospores (Table 10, II). Ordinarily these form on *Dryopteris spinulosa* and *D. spinulosa intermedia* throughout most of the localities with which I am familiar in the spring on overwintered fronds, but I have recently discovered that some at times develop in the fall on fronds of the current season.

Equally significant variations have been observed in what I take to be *M. fructuosa* as originally defined with respect to the relative abundance of uredinia (Table 10, I). Ordinarily these occur abundantly on *D. spinulosa americana* and *D. spinulosa fructuosa;* but in the upper

reaches of Whiteface Mountain of the Adirondacks I found on *D. spinulosa americana* a complete lack of them on the majority of affected fronds.

Owing to the absence of sharply cut morphological differences between *M. intermedia* and *M. fructuosa,* the modifications noted above serve to break down clear distinctions between them. My tentative conclusion is that *M. intermedia* and *M. fructuosa* as originally defined refer to different manifestations of the same rust species, manifestations that appear to be determined by host or climatic factors. The name *M. fructuosa* has priority. Its definition then should be amended by stating that uredinia vary in occurrence from none to many, in morphology from few-spored, vesicular, depauperate to many-spored, pustular, fairly conspicuous, and that teliospores form in the fall on fronds of the current season, or in spring on overwintered fronds, or part in the fall and part in the spring.

Pondering on the factors that determine the formation of teliospores in Milesian rusts one thinks of such interesting work as was accomplished by Waters (9) on the subject of this phenomenon in certain other rusts. Waters recorded that for nine species of rusts studied by him teliospore and uredospore formation could be influenced by experimental methods. He stated as part of his summary that teliospores were formed when "the host plants were placed under environmental conditions unfavorable for their development." It will be interesting to learn to what extent the metabolic state of the host determines teliospore formation in Milesian rusts, a state that in some hosts presumably would be attained in the fall, in others in the spring only after the fronds had overwintered. In the absence of direct observation on this point conclusions would be speculative, particularly when we know of such rusts as *Melampsorella Caryophyllacearum* and *Hyalopsora Aspidiotus* in which teliospores form solely in unfolding young leaves in the spring, leaves in which metabolic conditions would appear to be at their best.

6. Teliospores of *M. fructuosa* formed in the fall could not be made to germinate before the onset of winter. Evidently they require a resting period and their natural time for germination is in the following spring at the time the needles of *Abies* are unfolding.

7. Evidence is accumulating that species of *Milesia* are not closely restricted with respect to the species of *Abies* they may infect. This paper records (Table 7) successful inoculations of *M. fructuosa* on *A. amabilis, A. balsamea, A. cephalonica, A. concolor, A. Fraseri, A. Fra-*

seri prostrata, A. magnifica and *A. nephrolepis*—a list of hosts comprised of representatives from eastern North America, western North America, Europe and Asia.

On the other hand evidence is accumulating that species of *Milesia* are much more closely restricted with respect to their fern hosts. This paper records the results of experiments pertaining to this question in which three species were tested each on several species of ferns. (a) *Milesia intermedia* from *Abies balsamea* was inoculated on to *Dryopteris spinulosa, D. spinulosa intermedia, D. marginalis, D. cristata, D. fragrans* and *Polystichum acrostichoides;* infection resulted on *D. spinulosa* and *D. spinulosa intermedia* only (Table 2). (b) *M. marginalis* from *Abies balsamea* was inoculated on to *D. marginalis, D. cristata, D. spinulosa, D. spinulosa intermedia, Polystichum acrostichoides* and *Polypodium virginianum;* infection resulted on *D. marginalis* only (Table 4). (c) *Milesia polypodophila* from *Abies balsamea* was inoculated on to *Polypodium virginianum, Dryopteris marginalis* and *D. spinulosa intermedia;* infection resulted on *P. virginianum* only (Table 6).

8. The reactions of the rust and the various species of *Abies* infected with *M. fructuosa* exhibited some differences. There were slight variations in the size and form of the spermogonia; but the type remained approximately constant. A greater difference was found in the distribution of the spermogonia, particularly on the needles of *Abies magnifica*. In this fir they were strikingly amphigenous, almost equally distributed over all surfaces of the affected needles and not as in the other firs characteristically hypophyllous. The rusted needles of three of the firs showed some distortion, namely, in *A. Fraseri, A. Fraseri prostrata* and *A. magnifica*. The greatest effect resulted on *A. magnifica*—marked distortion and dwarfing.

9. Economically certain Milesian rusts are of some importance with respect to the unfavorable effect they exercise on the natural reproduction of *Abies*. *Milesia polypodophila* and *M. fructuosa* are noteworthy examples. The former causes unsightly and worthless plants of *A. balsamea* and the latter may kill or hold in check seedlings and saplings where the balsam fir is associated with rusted ferns. It is apparent from culture experiments that *M. fructuosa* is potentially a menace to young *A. magnifica*. Whenever intensive studies are being conducted in regions in which *Abies* constitutes a part of the forest stand, for the purpose of quantitatively forecasting forest successions, fern rusts as influencing factors should not be disregarded.

BIOLOGY OF MILESIAN RUSTS

THE HELIOTYPE CORP. BOSTON

BIOLOGY OF MILESIAN RUSTS

THE HELIOTYPE CORP. BOSTON

BIOLOGY OF MILESIAN RUSTS

THE HELIOTYPE CORP. BOSTON

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EXPLANATION OF PLATES

(Photographs made by Mr. A. B. Hatch)

Plate 84

Milesia marginalis Faull and Watson. Inoculation experiment #180 (E. H. B.) of 1927. *Abies balsamea* inoculated with telial material from *Dryopteris marginalis* collected June 26, 1927. Date of inoculation June 29, 1927; first spermogonia July 17; fully mature peridermia August 13; harvested August 22, 1927. × 1. (Herbarium J. H. Faull no. 8497.)

Plate 85

Milesia marginalis Faull and Watson. Enlarged portion of Plate 1.

Plate 86

Milesia intermedia Faull on seedlings of *Abies balsamea* growing on the floor of the forest; natural infection. Collected September 12, 1925. Of the needles of the current season one needle only of the plant on the left and five only of the plant on the right will survive; all the others will succumb from the rust attack. × 1. (Herbarium J. H. Faull no. 7393.)

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A REMARKABLE SPRUCE RUST, PERIDERMIUM PARKSIANUM, N. SP.

J. H. FAULL

A spruce rust of exceptional interest from western North America has been brought to light in collections made by Mr. Harold E. Parks on *Picea sitchensis* Carr. The rust is a *Peridermium* and its spermogonia indicate that it is the haploid phase of a species of *Melampsoropsis*. But whatever its diploid phase may prove to be its spermogonial and aecial characters are sufficiently distinctive to separate it easily from other known spruce rusts. Hence, even though the name proposed, *Peridermium Parksianum*, will be superseded by the name of the diploid phase when the latter is determined, in accordance with the accepted nomenclatorial rules, there is ample justification for formal designation of the haploid phase. The most striking characters are those manifested by the spermogonia and the aeciospores. The former are triangular in vertical section and broad-based, resembling tiny Erlenmeyer flasks. Most of the aeciospores are elongated, commonly so much so as to be properly described as linear. Often they are somewhat curved and their tips are tapered, the shape suggesting that of a slightly curved *Closterium*. Occasional spores are even slightly sigmoid.

This rust is restricted to needles of the current season and is often very abundant. The lesions caused by it may involve entire needles or limited portions only; they are somewhat lighter green than normal by the time the spermogonia first appear, but eventually they are straw-colored. The spermogonia form in late spring or early summer. Specimens collected June 29, 1933 carry an abundance of spermogonia from which there is a copious outpouring of the globular to broadly ellipsoidal spermatia, still being actively produced (apparently catenulately) from the elongated, unbranched spermatiophores that crowd the interior of the spermogonia. The peridermia develop slowly. First signs of them in 1933 were evident August 25 but they were not mature until the middle of September or later. They occur over a comparatively long period. The earliest collection in my herbarium bears the date September 21 and the latest November 23, the latter carrying many of the yellow-orange aecia still unruptured.

I have attempted to culture the rust on *Rhododendron californicum*

Hook., which appears to be a likely host, but so far without success. The negative results cannot, however, be accepted as final because difficulty has been encountered in securing germination of the aeciospores.

Peridermium Parksianum is reported from Trinidad, California and Florence, Oregon. The description of the spermogonia given below is based on a collection (Herb. J. H. Faull, no. 11,076) from Trinidad, California made June 29, 1933; the description of the peridermia is based on material (no. 11,002; Herb. H. E. Parks, no. 4052) collected October 15, 1932 from the same locality and checked against materials collected likewise at Trinidad November 23, 1933 (no. 11,592) and September 24, 1933 (no. 11,540). All collections were made by Mr. Harold E. Parks, and the species is named in his honor.

Peridermium Parksianum Faull, n. sp.

Pycnidia hypophylla, numerosa in foliis hornotinis, biseriata, conspicua, immersa, parum prominula, mellea, dein rufo-brunnea, in facie verticali triangula, subepidermalia, 228-315 μ lata et 125-155 μ alta, plus minusve 260 × 140 μ; spermatia globosa vel ellipsoidea, 2.7-3.2 × 3.0-5.0 μ. Aecidia hypophylla, in foliis hornotinis, irregulariter biseriata, maculis flavis insidentia, cylindracea vel lateraliter compressa, 0.4-1.2 mm. longa et 1.0-2.2 mm. alta, ad apicem dehiscentia; cellulae peridii albae, subimbricatim positae, 18-26 × 48-88 μ, pariete exteriore levi, 0.7-1.0 μ crasso, interiore dense et subtiliter verrucoso, circa 1.5 μ crasso; aecidiosporae fusiformes vel anguste ellipsoideae, rarius subglobosae, rectae vel curvulae, flavae, 13-24 × 25-111 μ, praecipue fusiformes et plus minusve 16 × 70 μ, dense et subtiliter verrucosae, episporio circa 1 μ crasso.

Hab. in foliis *Piceae sitchensis* in California et Oregon Americae bor.

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NOTES

The Beach Plum in Michigan. — In September 1932 we received for identification from Mr. James E. Armstrong of Chicago, fragmentary material of a plum that he had found growing on gravelly ridges in Lake County, west-central Michigan. From the somewhat withered leaves and the fruit this appeared to be a form of the variable beach plum (*Prunus maritima* Wang.), which has been previously known only from a limited area along the Atlantic coast from Maine to Virginia, where it grows, usually as a straggling shrub, along beaches and on sand dunes not far from the sea.

In subsequent correspondence with Mr. Armstrong he stated that the Michigan plum formed thick clumps of shrubs about six feet tall, and that it was apparently local and not very abundant in the vicinity of Walhalla, in the Lake region.

On my trip to the west this year, in company with Mr. E. D. King, I visited the region, and following the careful directions of Mr. Armstrong had no difficulty in locating the place and finding the plum, although not in the exact locality where he had found it.

Walhalla is a village in Lake County, about twenty or twenty-five miles east of Luddington, which is on Lake Michigan. The region is glaciated and includes a number of small lakes. Most of the sandy and gravelly uplands, where not cleared, are covered with a mixed growth of coniferous and deciduous forest.

Where we found the plums, a mile or two south of the village, they seemed to be locally abundant in openings of the sandy upland woods. The shrubs are usually scattered and are seldom more than four or five feet in height. They were in young fruit at the time of our visit, June 19th, but due apparently to a frost a short time before, most of the fruit was blighted, except in a few protected places where it was still abundant. I was told by a resident that the sand plums, as they seem to be called in that section, were common and that they were gathered for making jams and jellies.

A series of herbarium specimens was made and living plants were secured for propagation at the Arboretum. Study of this material and observation of the plants in the field leave no doubt as to their identity and confirms this interesting and remarkable extension of the known range of the beach plum. — ERNEST J. PALMER.

Quercus ellipsoidalis in Missouri. — While collecting last summer in northern Missouri, in company with Dr. Julian A. Steyermark, we came upon an oak in Harrison County of a species that apparently had not been previously found or reported for the state. The distribution of the jack oak (*Quercus ellipsoidalis* E. J. Hill) and its relation to that of the scarlet oak (*Q. coccinea* Muenchh.) has recently been worked out and discussed in an interesting manner by Mr. S. C. Wadmond.[1] On the distribution map accompanying his paper the range of the jack oak is shown as extending from northern Indiana, across Michigan, Wisconsin, northern Illinois, Minnesota and Iowa, with several records in the last named state immediately north of the Missouri locality reported here.

Harrison County, one of the border counties of northwestern Missouri, is in a glaciated region underlaid by Pennsylvanian formations of sandstones, shales, and limestones, and the topography and general character of the country, and that of the immediate locality, on the border of prairie and upland forest where *Quercus ellipsoidalis* was found, are quite characteristic for the species. Only a single tree was noted on our hurried trip, but no doubt others could be found in the vicinity, and the species should be looked for in other northern counties of Missouri, where a number of other northern plants reach their southern limits west of the Mississippi. — ERNEST J. PALMER.

[1]Trans. Wisconsin Acad. Sci. Arts and Letters, **28**:197–203 (1933).

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NOTES ON THE LIGNEOUS PLANTS DESCRIBED BY LEVEILLE FROM EASTERN ASIA[1]

ALFRED REHDER

ELAEOCARPACEAE

Sloanea sinensis (Hance) Hu in Jour. Arnold Arb. v. 230 (1924).

Castanopsis Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 506 (1913); Fl. Kouy-Tchéou, 125 (1914). — Camus, Châtaigniers, 375, 484 (1929). — **Synon. nov.**

Sloanea Hanceana Léveillé, Fl. Kouy-Tchéou, 420 (1915), vix Hemsley.

Sloanea chengfengensis Hu in Sinensia, III. 85. (1932). — **Synon. nov.**

CHINA. Kweichou: sud de Pin-fa, *J. Cavalerie,* no. 2514, Sept. 24, 1905 "arbre moyen, rare" (holotype of *Castanopsis Cavaleriei;* merotype in A. A.); Yang-kia-wan, Cheng-feng, in mixed woods, *Y. Tsiang,* no. 4641, Oct. 17, 1930 "tree 27 m., bark grey; fruit red" (holotype of *S. chengfengensis;* isotype in A. A.).

In his Flore du Kouy-Tchéou Léveillé enumerates Cavalerie's no. 2514 under *Castanopsis Cavaleriei* and also under *Sloanea Hanceana. Castanopsis Cavaleriei* had been already referred to *Sloanea* by Handel-Mazzetti (Symb. Sin. VII. 29, 1929) as *Sloanea* sp.; by A. Camus, l. c., it is enumerated as a doubtful species. *Sloanea Hanceana* Hemsl. = *S. Hemsleyana* (Ito) Rehd. & Wils. is very close to *S. sinensis* from which it differs chiefly in its larger leaves, serrate to near the base and in the shorter, slenderer and denser spines of the fruit.

I am unable to distinguish *Sloanea chenfengensis* from *S. sinensis.* Hu says it differs chiefly in the glabrous leaves and in the 4-celled fruits, but in *S. sinensis* the number of locules varies as in most species between 4 and 6 and the leaves are called by Hance in the original description "glaberrima" and so they are in all the specimens examined.

[1]Continued from p. 27; for preceding parts see Vol. X. 108-132, 184-196; XII. 275-281; XIII. 299-332; XIV. 223-252.

TILIACEAE

Tilia tuan Szyszylowicz in Hooker, Icon. Pl. XX. t. 1926 (1890).

Tilia tuan var. *Cavaleriei* V. Engler & Léveillé in Fedde, Rep. Spec. Nov. VI. 266 (1909). — V. Engler, Monog. Tilia, 124 (1909). — Schneider, Ill. Handb. Laubholzk. II. 389 (1909). — Léveillé, Fl. Kouy-Tchéou, 420 (1915).

CHINA. Kweichou: Pin-fa, montagnes, au sud, *Cavalerie* no. 3227, May 30, 1907, "vu 7 ou 8 petits arbres, fl. blanc-jaune" (holotype of *T. tuan* var. *Cavaleriei;* photo. in A. A.).

Tilia tuan var. *Cavaleriei* represents the type of *T. tuan* according to Engler who has it as "var. α," and to Schneider. It differs only slightly from the type specimen in the somewhat narrower leaves, the upper ones measuring 9.5 by 4 cm. to 12 by 5.5 cm.

Tilia Miqueliana Maximowicz in Bull. Acad. Sci. St. Pétersb. XXVI. 434 (1880); in Mél. Biol. X. 687 (1880). — V. Engler, Monog. Tilia, 111 (1909).

Tilia Kinashii Léveillé & Vaniot in Bull. Sci. Bot. France, XLI. 422 (1904).

CENTRAL JAPAN: *Kinashi* no. 2, (holotype of *T. Kinashii*; photo. in A. A.).

Tilia Kinashii was already referred to *T. Miqueliana* by V. Engler and according to a note on the type specimen also by G. Koidzumi.

Grewia biloba G. Don, Gen. Syst. I. 549 (1831). — Handel-Mazzetti, Symb. VII. 612 (1933).

Grewia glabrescens Bentham, Fl. Hongk. 42 (1861). — Léveillé, Fl. Kouy-Tchéou, 419 (1915).

Grewia Esquirolii Léveillé, Fl. Kouy-Tchéou, 419 (1915), pro synon.

Celastrus euonymoides Léveillé, l. c. (1915), pro synon.

Grewia parviflora var. *glabrescens* Rehder & Wilson in Sargent, Pl. Wilson. II. 371 (1915).

CHINA. Kweichou: Gou-réou, *J. Esquirol,* no. 3189, Dec. 1911 (probable type of *G. Esquirolii;* photo. in A. A.); Lo-fou rivière, *J. Cavalerie,* no. 3513, April 1909, "arb. 2 m." (type of *Celastrus euonymoides;* photo. in A. A.); same locality, *J. Esquirol,* no. 2204, Sept. 1910, and *J. Cavalerie,* no. 3492, Aug. 1909.

Grewia Esquirolii and *Celastrus euonymoides* are apparently manuscript names published only as synonyms of *G. glabrescens;* the name *C. euonymoides* appears on the label of Cavalerie's no. 3513, but on Esquirol's no. 3189 no name appears except *Euonymus* which is crossed out. Esquirol's no. 2204 is named *G. glabrescens* Benth. in Léveillé's handwriting, while Cavalerie, no. 3492, bears no name except "Grewia?", but was placed in the cover of *G. glabrescens*.

I am following Handel-Mazzetti in considering *Grewia glabrescens* identical with *G. biloba*. Don describes the leaves as smooth above, but pubescent beneath, which agrees with Bentham's description of the leaves as glabrous or sparingly sprinkled with a few short hairs on the upper side and dotted with a minute stellate pubescence underneath, while Bunge describes the leaves of his *G. parviflora* as "supra hispidulis, subtus stellato-canescentibus." The latter, therefore, becomes a variety of *G. biloba*. The two varieties, however, cannot be sharply separated and are closely connected by intermediate forms. There is also a difference in the shape; typical *G. biloba* has the leaves generally longer, oblong-oval to oblong-lanceolate, while those of var. *parviflora* are shorter and broader, ovate or oval, and usually smaller.

Grewia biloba var. **parviflora** (Bge.) Handel-Mazzetti, Symb. Sin. VII. 612 (1933).

Grewia biloba Burret in Notizbl. Bot. Gart. Mus. Berlin, IX. 708 (1926). — Rehder in Jour. Arnold Arb. VIII. 173 (1927).

Rubus umbellifer Léveillé in Fedde, Rep. Spec. Nov. VI. 111 (1908); in Bull. Acad. Intern. Géog. Bot. XIX. Mém. 16 (Ronces Chin. Jap.) (1909). — **Synon. nov.**

Grewia Chanetii Léveillé in Fedde, Rep. Spec. Nov. X. 147 (1911).

CHINA. Hopei: Kia-chan, *L. Chanet*, no. 571, Aug. 1910 (holotype of *G. Chanetii;* photo. in A. A.); mont de Pong-chan, *L. Chanet*, June 15-16, 1910 (in herb. Léveillé sub *G. Chanetii;* photo. in A. A.). Yunnan: près Pin-tchouan, *Jean Py* in herb. Ducloux, no. 618, April 27, 1906, "fleurs jaunes" (holotype of *Rubus umbellifer* in Herb. Univ. Calif.; photo. in A. A.).

The specimen from Yunnan approaches the type, but is rather densely pilose above and most of the leaves are oval or elliptic. *Grewia Chanetii* had been already identified as *G. biloba* by Burrett (l. c.).

Grewia abutilifolia Ventenat apud Jussieu in Ann. Mus. Paris, IV. 92 (1804). — Burrett in Notizbl. Bot. Gart. Mus. Berlin, IX. 723 (1926).

Sterculia tiliacea Léveillé in Fedde, Rep. Spec. Nov. XII. 185 (1913); Fl. Kouy-Tchéou, 406 (1915). — **Synon. nov.**

CHINA. Kweichou: canal d'eau en amont de Ouang-mou, *J. Esquirol*, no. 47, May 26, 1904, "arbrisseau, fl. jaunes" (holotype of *Sterculia tiliacea;* photo. in A. A.).

The leaves of the specimen cited are very broad, some even broader than long, about 9 cm. long and 10 cm. broad, and some show a slight tendency toward lobing, as in Henry's no. 9887D which was identified by Burrett (l. c.) with *G. abutilifolia*.

MALVACEAE

Abutilon indicum (L.) Sweet, Hort. Brit. 54 (1827). — Léveillé, Cat. Pl. Yun-Nan, 175 (1916).

Abutilon Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 185 (1913); Fl. Kouy-Tchéou, *272* (1914). — **Synon. nov.**

CHINA. Kweichou: ouest de Lo-fou, *J. Cavalerie,* Nov. 1905 (holotype of *A. Cavaleriei;* photo. in A. A.).

Urena lobata Linnaeus, Spec. Pl. 692 (1753). — Léveillé, Fl. Kouy-Tchéou, 275 (1914); Cat. Pl. Yun-Nan, 176 (1916).

Abutilon Esquirolii Léveillé in Bull. Géog. Bot. XXIV. 252 (1914); Fl. Kouy-Tchéou, *272* (1914). — **Synon. nov.**

CHINA. Kweichou: Gou-réou, dans les herbages, rare, 700 m., *J. Esquirol,* no. 3668, Sept. 1912, "haut 1.5-2 m., fl. roses" (holotype of *Abutilon Esquirolii;* merotype in A. A.).

A form with ovate to orbicular-ovate undivided only sparingly denticulate leaves and the flowers clustered at the apex of the branches, not axillary along the stems.

Hibiscus Labordei Léveillé in Fedde, Rep. Spec. Nov. XII. 184 (1913); Fl. Kouy-Tchéou, 274 (1914).

CHINA. Kweichou: montagne de Kao-po (Tsin-gay), *J. Laborde* in herb. Bodinier, Sept. 10, 1899 "grand arbuste" (holotype; photo. in A. A.).

This species I have not been able to identify with any of the described species; it seem to be nearest to *H. mutabilis* L. from which it differs chiefly in the 3-lobed leaves, the short pedicels 1-1.5 cm. long, and in the dense ochraceous tomentum of the calyx which is about as long as the 6 linear-lanceolate bracts.

Hibiscus crinitus (Wall.) G. Don, Gen. Syst. I. 480 (1831).

Hibiscus cancellatus Roxburgh, Hort. Bengal. 51 (1814), nom. nud.; Fl. Ind. III. 201 (1832). — Hochreutiner in Ann. Jard. Bot. Genève, IV. 149 (1900). — Léveillé, Cat. Pl. Yun-Nan, 175 (1916). — Non Linnaeus f.

Hibiscus Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 184 (1913); Fl. Kouy-Tchéou, *274* (1914). — **Synon. nov.**

Hibiscus Bodinieri Léveillé, l. c. (1913); l. c., *273* (1914); Cat. Pl. Yun-Nan, 175 (1916). — **Synon. nov.**

CHINA. Kweichou: montagnes de Lo-fou, *J. Cavalerie,* no. 2584, Nov. 1905 (holotype of *H. Cavaleriei;* photo. in A. A.); Hoa-kiang, *J. Cavalerie,* no. 3959, July 1912 (cited in Fl. Kouy-Tchéou under *H. Cavaleriei;* dupl. in A. A.); Kouy-yang, descente du fleuve, *E. Bodinier,* no. 503, July 27, 1900, "fl. jaunes" (syntype of *H.*

Bodinieri; merotype in A. A.); without locality, *J. Esquirol,* no. 89, June 13, 1904 (syntype of *H. Bodinieri;* photo. in A. A.).

Hibiscus cancellatus Roxb. is a later homonym of *H. cancellatus* Linnaeus f. Suppl. 311 (1781) = *Pavonia cancellata* (L. f.), and also a later synonym of *H. crinitus* (Wall.) G. Don, since its valid publication dates from 1832; therefore, *H. crinitus* (Wall.) G. Don is the correct name for this species.

Hibiscus sagittifolius Kurz var. **septentrionalis** Gagnepain in Lecomte, Fl. Gén. Indo-Chine, I. 435 (1910); Handel-Mazzetti, Symb. Sin. VII. 609 (1933).

Hibiscus Bodinieri var. *brevicalyculata* Léveillé in Fedde, Rep. Spec. Nov. XII. 184 (1913). — **Synon. nov.**

Hibiscus Esquirolii Léveillé, l. c. (1913); Fl. Kouy-Tchéou, 274 (1914).

Hibiscus bellicosus Léveillé, Fl. Kouy-Tchéou, 273 (1914).

CHINA. Kweichou: Kouy-yang, descente du fleuve, *E. Bodinier,* no. 504, July 27, "fl. rouge" (syntype of *H. Bodinieri* var. *brevicalyculata* and holotype of *H. bellicosus;* photo. in A. A.); same locality, *J. Esquirol,* no. 90, June 13, 1904, "fl. rose" (syntype of *H. Bodinieri* var. *brevicalyculata;* photo. in A. A.); montagnes près de Houa-kiang, *J. Cavalerie,* no. 2047, June 1904, and *J. Esquirol,* no. 531, June 1905 (syntypes of *H. Esquirolii;* photo. in A. A.).

Hibiscus Esquirolii has been already referred to this variety by Handel-Mazzetti (l. c.). *Hibiscus bellicosus* was based by *Léveillé* on his *H. Bodinieri* var. *brevicalyculata.*

STERCULIACEAE

Eriolaena malvacea (Lévl.) Handel-Mazzetti, Symb. Sin. VII. 613 (1933).

Sterculia malvacea Léveillé in Fedde, Rep. Spec. Nov. XII. 185 (1913).

Eriolaena sterculiacea Léveillé, Fl. Kouy-Tchéou, 405 (1915).

Eriolaena szemaoensis Hu in Jour. Arnold Arb. v. 230 (1924); in Contrib. Biol. Lab. Sci. Soc. China, 1 no. 2, p. 1 (1925). — **Synon. nov.**

CHINA. Kweichou: Kiao-ta, 750 m., *J. Esquirol,* no. 2185, June 1910 (holotype of *Sterculia malvacea* and *Eriolaena sterculiacea;* photo. in A. A.). Yunnan: Szemao, western mountains, 5000 ft., *A. Henry,* no. 11873 (flowers) "tree 15 ft." (holotype of *E. szemaoensis;* isotype in A. A.); same locality, *A. Henry,* nos. 12506, 12506A, 12506B (fruit) "tree 15 ft." (paratypes of *E. szemaoensis;* isotypes in A. A.).

When transferring his *Sterculia malvacea* to *Eriolaena* Léveillé changed the specific epithet to "*sterculiacea*." The same species was found by Handel-Mazzetti on the road from Yunnan-fu to Talifu (no. 8649).

Reevesia pubescens Masters in Hooker f., Fl. Brit. Ind. I. 364 (1874). — Rehder & Wilson in Sargent, Pl. Wilson. II. 376 (1915). — Léveillé, Cat. Pl. Yun-Nan, 267 (1917). — Anthony in Notes Bot. Gard. Edinb. xv. 124 (1926). — Rehder in Jour. Arnold Arb. x. 196 (1929).

Reevesia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IV. 330 (1907); Fl. Kouy-Tchéou, 405 (1915).

Capparis masaikai Léveillé, Fl. Kouy-Tchéou, 59 (1914), pro parte, quoad Cavalerie, no. 3347 [= 2347].

Reevesia thyrsoidea Léveillé, Fl. Kouy-Tchéou 405 (1915). — Non Lindley.

CHINA. Kweichou: route de Pin-fa à Kouy-yang, bois, très rare, *J. Cavalerie*, no. 2347, May 20, 1905 (holotype of *R. Cavaleriei* and syntype of *Capparis masaikai;* merotype in A. A.).

Reevesia Cavaleriei was first identified with *R. pubescens* by Anthony (l. c.), who also reduced *R. sinica* Wils., *R. siamensis* Craib and *Eriolaena yunnanensis* W. W. Sm. to synonyms of *R. pubescens*. Léveillé in his Flore du Kouy-Tchéou made the same number, erroneously cited as no. 3347, one of the two syntypes of his *Capparis masaikai*.

Helicteres glabriuscula Wallich, Num. List. no. 1185 (1828), nom. nud. — M. T. Masters in Hooker f. Fl. Brit. Ind. I. 366 (1874).

Corchorus Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. x. 437 (1912). —**Synon. nov.**

Helicteres Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 534 (1913); Fl. Kouy-Tchéou, 405 (1915).

CHINA. Kweichou: Lo-fou, *J. Cavalerie*, no. 3470, March 1909 (holotype of *Corchorus Cavaleriei* and *Helicteres Cavaleriei;* merotype in A. A.); Goui-reou, *J. Esquirol*, no. 3180, Dec. 14, 1911, "tout petit frutex" (cited under *Helicteres Cavaleriei;* photo. in A. A.).

This Himalayan species occurs also in Yunnan (Henry, nos. 11185 and 12218A).

DILLENIACEAE

Actinidia purpurea Rehder in Sargent, Pl. Wilson. II. 378 (1915).

Actinidia arguta Planch. (*A. rufa* Miq.) ex Miq. var. *Dunnii* Léveillé, Cat. Pl. Yun-Nan, 269 (1917).

Léveillé cites "*arguta* Dunn" as synonym of his var. *Dunnii* without description or reference to specimens. Dunn's *A. rufa* var. *arguta* is

based on *A. arguta* Miq. and its range is given as including Manchuria, Japan, Korea and China southwest to Yunnan. I assume that Léveillé's intention was to separate as a distinct variety the Yunnan specimens cited by Dunn under var. *arguta*. Dunn cites three specimens from Yunnan, *Delavay*, no. 4264 and *Henry*, nos. 9694 and 11008; the first I have not seen, the two Henry specimens belong to my *A. purpurea*, no. 11008 being cited as a paratype.

Actinidia Fortunati Finet & Gagnepain in Bull. Soc. Bot. France, LIII, 574, fig. 1, 9-16, (1906). — Léveillé, Fl. Kouy-Tchéou, 413 (1915).

Actinidia Dielsii Léveillé in Fedde, Rep. Spec. Nov. XIII. 175 (1914).

CHINA. Kweichou: Pin-fa, montagnes, *J. Cavalerie*, no. 12 bis, June 3, 1902 (syntype of *A. Dielsii;* photo. in A. A.); same locality, *J. Cavalerie*, no. 1746, in 1904 (syntype of *A. Dielsii;* ex Léveillé).

Actinidia Dielsii was referred to *A. Fortunati* by Léveillé in his Flore du Kouy-Tchéou.

Actinidia Rubus Léveillé in Fedde, Rep. Spec. Nov. XII. 282 (1913); Cat. Pl. Yun-Nan, 270 (1917).

CHINA. Yunnan: bois de Sen-choui-lin (Tchao-tong), alt. 2000 m., *E. E. Maire*, June 1912 "arbuste grimpant, rameaux ciliés, fl. jaunes" (holotype; merotype in A. A.).

This species seems nearest to *A. holotricha* Fin. & Gagnep. from which it differs in its larger, ovate to obovate acuminate leaves to 10 cm. long, sparingly setose above, hispid on the midrib beneath and slightly so on the lateral veins, in the 5-6 cm. long petioles and in the sepals being glabrous outside.

Actinidia lanata Hemsley in Ann. Bot. IX. 146 (1895).

Ficus hirtaeformis Léveillé & Vaniot in Mem. Acad. Ci. Art. Barcelona, ser. 3, VI. 150 (reprint, p. 12) (1907); in Fedde, Rep. Spec. Nov. IV. 84 (1907); Fl. Kouy-Tchéou, 430 (1915). — **Synon. nov.**

Mespilus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XII. 188 (1913); Fl. Kouy-Tchéou, 348 (1915). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, montagnes, *J. Cavalerie*, no. 1593, in 1904 (holotype of *Ficus hirtaeformis;* photo. in A. A.); Pin-fa, ruisseau des barbares, *J. Esquirol*, no. 409, June 1905, "arbrisseau sarmenteux, fl. jaunâtre" (syntype of *Mespilus Esquirolii;* photo. in A. A.); Pin-fa, Niang-ouong, bois, montagnes, *J. Esquirol*, no. 2346, June 8, 1905, "fl. jaune paille, orange" (syntype of *M. Esquirolii;* photo. in A. A.).

According to Handel-Mazzetti (Symb. Sin. VII. 392) Cavalerie, no. 4346, from Pin-fa (in herb. Paris) was determined by Gagnepain as *A. lanata*.

THEACEAE

Thea Costei (Lévl.), comb. nov.

Camellia Costei Léveillé in Fedde, Rep. Spec. Nov. x. 148 (1911); Fl. Kouy-Tchéou, 414 (1915). — C. P. Cohen Stuart in Bull. Gard. Bot. Buitenz. sér. 3, I. 239, 244 (1919).

Thea chinensis Seem. var. *androxantha* Léveillé, Cat. Pl. Yun-Nan, 271 (1917). — **Synon. nov.**

CHINA. Kweichou: Hang-tong, *J. Esquirol*, no. 303, Jan. 26, 1905, "arbrisseau, fl. très blanches, feuillage très vert" (holotype of *Camellia Costei;* merotype in A. A.); Pin-fa, *J. Cavalerie* no. 785, March 6, 1902, "fl. blanches" (cited in Fl. Kouy-Tchéou under *C. Costei;* duplicate in A. A.). Yunnan: brousse de coteaux à Long-ky, alt. 500 m., *E. E. Maire*, May [1911-13], "petit arbre à branches delicates" (holotype of *Thea chinensis* var. *androxantha;* merotype in A. A.).

This species is closely related to *Th. cuspidata* Kochs from which it is chiefly distinguished by the thinner leaves with the veins beneath slightly elevated and by the filaments being united about one half. The specimen of *Th. chinensis* var. *androxantha*, however, resembles in the thicker texture of its leaves *Th. cuspidata*, but the stamens are united, at least partly, to about the middle.

Thea oleosa Loureiro, Fl. Cochinch. 339 (1790). — Merrill, Comm. Lour. Fl. Cochinch. (1921) MS.

Thea oleifera (Abel) Rehder & Wilson in Sargent, Pl. Wilson. II. 393 (1915).

Thea podogyna Léveillé, Sert. Yunnan. 2 (1916); Cat. Pl. Yun-Nan, 271 (1917). — **Synon. nov.**

CHINA. Yunnan: brousse de Tcheng-fong-chan, 800 m., *E. E. Maire*, May 1912, "grande arbuste, toujours vert, fl. blanches" (holotype of *Th. podogyna;* merotype in A. A.).

Thea Grijsii (Hce.) Kochs in Bot. Jahrb. XXVII. 591 (1900).

Thea Cavaleriana Léveillé, Cat. Pl. Yun-Nan, 271, in nota (1917). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, montagnes, *J. Cavalerie*, no. 757, Dec. 9, 1902, "fl. blanches, legèrement roses à l'extérieur" (holotype of *Th. Cavaleriana;* merotype in A. A.).

Thea Pitardii (Stuart) Rehder in Jour. Arnold Arb. v. 238 (1924).

Thea speciosa Pitard apud Diels in Notes Bot. Gard. Edinb. v. 285 (1912). — Non Kochs.

Camellia japonica Léveillé, Fl. Kouy-Tchéou, 414 (1915), tandem pro parte. — Non Linnaeus.

Thea Mairei Léveillé, Sert. Yunnan. 2 (1916); Cat. Pl. Yun-Nan, 271 (1917). — **Synon. nov.**

China. Kweichou: Tou-chan, J. Cavalerie in herb. Bodinier, no. 2594, Aug. 1912 (cited in Fl. Kouy-Tchéou under *C. japonica*, isotype of *Th. speciosa* Pitard apud Diels.). Yunnan: collines de Tchen-fong-chan, 550 m., *E. E. Maire*, May 1912 "arbre de taille moyenne, feuilles luisantes, fl. simple, rouge-vif" (holotype of *Th. Mairei;* merotype in A. A.).

The specimens cited by Léveillé under *Camellia japonica* belong without doubt all to *Thea Pitardii* as does Cavalerie's no. 2594 which is a duplicate of the type of *Th. Pitardii* in the Paris Herbarium. *Thea japonica* (L.) Nois is not found in western China.

As already pointed out by Dr. Handel-Mazzetti (Symb. Sin. VII. 393) *Thea Pitardii* is exceedingly variable in the shape and size of the leaves, in the pubescence of the sepals and also in the color of the flowers, which vary from bright red to white. In the typical form the leaves are generally oblong, 5-10 cm. long and acuminate to long acuminate with the veins above slightly raised and less so beneath; the sepals are densely silky outside and also the petals are more or less silky outside. As an extreme form the following may be distinguished:

Thea Pitardii var. **lucidissima** (Lévl.), comb. nov.

Thea Camellia Lévl. var. *lucidissima* Léveillé, Cat. Pl. Yun-Nan, 270 (1917).

China. Yunnan: montagnes arides herbeuses, autour de Tong-chouan, 2700 m., *E. E. Maire,* Feb. 1912 "arbuste toujours d'un vert luisant" (holotype of *Th. Camellia* var. *lucidissima;* merotype in A. A.).

This variety differs from the typical form in the smaller leaves, usually 3.5-6 cm. long, acute or even obtusish, of thicker texture and usually very lustrous with the veins above mostly impressed, and in the glabrous or glabrescent bracts, sepals and petals. The following specimens in this herbarium from Yunnan seem referable to this variety: Rock, nos. 3045, 3105, 7910, 7941, 8062, 8169, 8469, 11721, 11722 and G. Forrest, nos. 8024 and 26285. In other specimens the leaves are like those of the typical form but the sepals and petals are glabrous or nearly so as in Rock nos. 8237, 8239, 11673 and 11716; these are probably better referred to the type and may constitute a distinct form.

Eurya nitida Korthals, Kruidk. in Verh. Nat. Geschied. Bot. 115, t. 7 (1840). — Handel-Mazzetti, Symb. Sin. VII. 399 (1831).

Rapanea aurea Léveillé in Fedde, Rep. Spec. Nov. x. 376 (1912); Fl. Kouy-Tchéou, 288 (1914). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, montagne, *J. Cavalerie,* no. 839, March 10, and no. 841, Feb. 27, 1902 "fl. blanc-sombres ou blanches" (syntypes of *Rapanea aurea;* photo. in A. A.).

The two specimens differ slightly in the shape of the leaves; no. 839 has oblong leaves with a short but distinct obtuse acumen, while no. 841 has somewhat broader generally elliptic-oblong and not or hardly acuminate leaves.

GUTTIFERAE

Hypericum patulum Thunberg, Fl. Jap. 295 (1784). — Léveillé in Bull. Soc. Bot. France, LIV. 591 (1907); Cat. Pl. Yun-Nan, 133 (1916); in Mem. Acad. Ci. Barcelona, ser. 3, XII. 553 (Cat. Pl. Kiang-Sou, 13) (1916).

Hypericum Argyi Léveillé & Vaniot in Bull. Soc. Bot. France, LIV. 591 (1907); Fl. Kouy-Tchéou, 198 (1914); in Mem. Acad. Ci. Barcelona, ser. 3, XII. 553 (Cat. Pl. Kiang-Sou, 13 (1916). — **Synon. nov.**

CHINA. Kiangsu: without precise locality, *Ch. d'Argy* [1846-66] (holotype of *H. Argyi;* photo. in A. A.). Kweichou: Hoang-tsao-pa, près des cours d'eaux, *J. Esquirol,* no. 1552, June 1909 (cited in Fl. Kouy-Tchéou under *H. Argyi;* merotype in A. A.).

Hypericum Argyi has been already referred to *H. patulum* by G. Koidzumi according to a note on the type specimen. In his key Léveillé (l. c.) distinguishes *H. patulum* from *H. Argyi* chiefly by the acute sepals, but they are obtuse in typical *H. patulum;* they are, however, acute or acutish in *H. patulum* var. *Henryi* Veitch.

Hypericum Hookerianum Wight & Arnott, Prodr. Fl. Ind. 99 (1834). — Léveillé in Bull. Soc. Bot. France, LIV. 590 (1907); Cat. Pl. Yun-Nan, 133 (1916).

Hypericum Henryi Léveillé & Vaniot in Bull. Soc. Bot. France, LIV. 590 (1907). — Léveillé, Fl. Kouy-Tchéou, 198 (1914); Cat. Pl. Yun-Nan, 133 (1916). — **Synon. nov.**

CHINA. Kweichou: environs de Kouy-yang, partout dans les montagnes, *E. Bodinier,* no. 1933, Aug. 1897, "gr. fleurs jaunes" (holotype of *H. Henryi;* photo. in A. A.).

The type specimen of *H. Henryi* cited above bears the name *H. patulum* with a note "d'après Dr. Henry" in Bodinier's handwriting, and the name *H. Henryi* does not appear on the sheet. Two other specimens, however, both from Yunnan and collected by E. E. Maire, bear the name *H. Henryi* in Léveillé's handwriting, but these are not identical with the type of *H. Henryi;* one of these, in the Léveillé

herbarium, is from Tong-tchouan, and the other, in the Herbarium Bonati, "Maire, no. 402, collines, Mai 1905," is without exact locality. Both belong apparently to *H. patulum* var. *Henryi* Veitch, though the leaves resemble those of var. *uralum* (Don) Koehne, but the flowers are quite large, 3-3.5 cm. across and the sepals are acutish to acuminate.

Hypericum longifolium Léveillé in Bull. Agric. Sci. Sarthe, XXXIX. 322 (Bouquet Fl. Chine, 7) (1904); in Fedde, Rep. Spec. Nov. VI. 372 (1909); in Bull. Soc. Bot. France, LIV. 590 (1907); Fl. Kouy-Tchéou, 199 (1914).

CHINA. K w e i c h o u : mont du Collège, dans la brousse, près de Ke-ma-tong, *E. Bodinier*, no. 1774, Aug. 9, 1897 "fl. jaunes" (holotype; photo. in A. A.).

I have not been able to identify *Hypericum longifolium* with a described species. It is similar to *H. chinenese* Lam., but differs in the quadrangular stem, linear-lanceolate gradually acuminate leaves, ovate obtuse sepals and shorter style more deeply divided at the apex, sometimes to 1/3. Léveillé enumerates the species among the frutescent ones, but it has the aspect and the stem of an herbaceous species.

Hypericum kouytchense Léveillé in Bull. Soc. Agric. Sarthe, XXXIX. 322 (Bouquet Fl. Chine 7) (1904); in Bull. Soc. Bot. France, LIV. 592 (1907); in Fedde, Rep. Spec. Nov. VI. 375 (1909); Fl. Kouy-Tchéou, 198 (1914). — Rehder in Jour. Arnold Arb. x. 134 (1929).

CHINA. K w e i c h o u : mont de Lou-tsong-koan, cc. dans la montagne, *E. Bodinier*, no. 1603, May 31, 1897, "belles fleurs jaunes" (holotype; merotype in A. A.).

This species belongs to the section Norysca and seems intermediate between *H. lysimachioides* Wall. and *H. patulum* Thbg. It has been also found near Wushan, eastern Szechuan, and plants raised from seed collected by E. H. Wilson in that locality are in cultivation. At the place cited above I published a description based chiefly on these cultivated plants.

FLACOURTIACEAE

Xylosma racemosum (Sieb. & Zucc.) Miquel in Ann. Mus. Bot. Lugd.-Bat. II. 155 (1865-66). — Léveillé, Fl. Kouy-Tchéou, 52 (1914); Cat. Pl. Yun-Nan, 20 (1915).

Crataegus Academiae Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 559 (Cat. Pl. Kiang-sou, 19) (1916). — **Synon. nov.**

CHINA. K w a n g s i : Souo-se, *Ch. d'Argy*, Sept. 1859? "arbuste verte" (holotype of *Crataegus Academiae;* merotype in A. A.).

The specimen cited above represents the typical form with glabrous ovate serrulate leaves. I am following Handel-Mazzetti (Symb. Sin. VII. 383) in rejecting as a nomen confusum, Loureiro's name *Croton congestum* on which Merrill based the combination *X. congestum,* since the fruit described is that of an euphorbiaceous plant and the habit given as suffruticose which does not agree with *Xylosma.*

Xylosma racemosum var. **kwangtungense** (Metcalf), comb. nov.

Xylosma Dunniana Léveillé in Fedde, Rep. Spec. Nov. IX. 455 (1911); Fl. Kouy-Tchéou, 52 (1914). — **Synon. nov.**

Flacourtia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 457 (1911); Fl. Kouy-Tchéou, 51 (1914). — **Synon. nov.**

Xylosma racemosa Léveillé, Fl. Kouy-Tchéou, 52 (1914), vix Miq.

Xylosma congestum var. *kwangtungense* Metcalf in Jour. Arnold Arb. XII. 272 (1931).

CHINA. Kweichou: Tsin-gai, *J. Cavalerie,* no. 1151, July 15, 1903 (holotype of *X. Dunniana;* merotype in A. A.); Pin-fa, bois, assez rare, *J. Cavalerie,* no. 3327, July 1908, "arbre épineux, fl. jaunes, inodores" (holotype of *Flacourtia Cavaleriei;* merotype in A. A.).

The specimens cited above were referred to by Dr. H. Sleumer (in litt.) to the var. *kwangtungense* with which they agree in their elliptic-oblong to lanceolate-oblong rather coarsely serrate leaves.

Carrierea Dunniana Léveillé in Fedde, Rep. Spec. Nov. IX. 458 (1911); Fl. Kouy-Tchéou, 51 (1914). — Gilg in Engler & Prantl, Nat. Pflanzenfam. ed. 2, XXI. 444 (1925).

CHINA. Kweichou: route de Pin-fa à Tou-yun, *J. Cavalerie,* no. 3001, Aug. 2, 1908, "arbre à fleurs blanches" (holotype; merotype in A. A.).

Carrierea Dunniana has been already enumerated as a valid species by Gilg (l. c.). It is easily distinguished from *C. calycina* Franch. by the many-flowered paniculate inflorescence, the much smaller sepals not cordate at the base, and the ovate-oblong to oblong rather long acuminate leaves. It has been collected also by Y. Tsiang (no. 5644) near Tuyun and distributed as *C. calycina.* As in *C. calycina* the flowers are dioecious, Cavalerie's no. 3001 being pistillate, while Tsiang's no. 5644 is staminate. The ovary of the pistillate flowers is one half to one third as long as the sepals which are about 8 mm. long and is surrounded at the base by anther-bearing staminodes about 1/3 as long as the ovary; the styles are longer and slenderer than in *C. calycina,* about half as long as the ovary. The stamens in the staminate flowers are very numerous and unequal, the longest about one third as long as the sepals, and bear in the middle a minute rudimentary

ovary. The structure of the flowers of *C. calycina* is similar, but in the staminate flowers the rudimentary ovary is lacking or occasionally lacking, at least there was none in a flower examined of Wilson's Veitch Exped. no. 1104. The staminate inflorescence may be occasionally paniculate by its lower branches becoming 3-flowered, while the pistillate inflorescence has fewer flowers and may become reduced to one or two flowers as in a specimen from Tchen-kéou-tin collected by Farges. Among the material in this herbarium I have seen no flower like that figured by Franchet with his original description, but the genus may be polygamous and plants with hermaphrodite flowers may occur.

STACHYURACEAE

Stachyurus yunnanensis Franchet in Jour. de Bot. XII. 253 (1898). — Léveillé, Cat. Pl. Yun-Nan, 270 (1917).

Stachyurus Esquirolii Léveillé, Fl. Kouy-Tchéou, 416 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Than-lo, 1100 m., *J. Esquirol,* no. 3517, March 20, 1912, "fleurs blanches" (holotype of *S. Esquirolii;* merotype in A. A.).

THYMELAEACEAE

Wikstroemia indica (L.) C. A. Meyer in Bull. Acad. Sci. St. Pétersb. sér. 2, I. 358 (1843).

Wikstroemia Valbrayi Léveillé, Fl. Kouy-Tchéou, 417 (1915); Cat. Ill. Pl. Seu-Tchouen, 199, t. 63 (1918) MS. — Rehder in Sargent, Pl. Wilson. II. 538 (1916). — **Synon. nov.**

CHINA. K w e i c h o u : Tsin-gay, mont., *J. Cavalerie,* no. 1261, Aug. 4, 1903, "fl. jaunes" (syntype of *W. Valbrayi;* photo. in A. A.); route de Pin-fa à Tin-fan, *J. Cavalerie,* no. 1865, Nov. 1904 (syntype of *W. Valbrayi;* photo. in A. A.).

Wikstroemia indica has been collected in Kweichou also by Y. Tsiang (no. 7150), by R. C. Ching in Kwangsi (nos. 6084 and 8172) and by Handel-Mazzetti (no. 10895) who also collected it in Hunan (no. 11297). Handel-Mazzetti cites Cavalerie, no. 1261, a syntype of *W. Valbrayi,* under *W. indica,* but does not quote Léveillé's name as a synonym.

Wikstroemia Vaccinium (Lévl.), comb. nov.

Lonicera Vaccinium Léveillé, Fl. Kouy-Tchéou, 64 (1914).

Frutex ramulis gracilibus sericeo-strigosis, vetustioribus nigro-purpureis. Folia opposita, decidua, breviter petiolata, elliptica vel ovato-elliptica, 5-10 mm. longa, apice obtusiuscula, basi late cuneata, supra glabra, subtus sparse strigosis, utrinque viridia, venis utrinsecus

circiter 3; petioli sericeo-strigosi, vix 1 mm. longi. Flores pauci in spica congesta terminali, pedunculo brevissimo vel in fructu ad 5 mm. longo; perianthii tubus extus sericeo-strigosus, 4 mm. longus, intus glaber, lobis 4 ovatis vix 1 mm. longis, antherae 4 (?), subsessiles; ovarium stipitatum, apice pilis setosis stylum brevem, obtegentibus ceterum glabrum, stigmate capitato; disci squama apice dentata. Fructus ellipsoideus, 4 mm. longus, glaber.

CHINA. K w e i c h o u : Pin-fa, très hautes montagnes, *J. Cavalerie,* no. 26, May 1902 "fl. roses" (holotype of *Lonicera Vaccinium;* merotype in A. A.).

This species seems closely related to *W. monnula* Hance, from which it is easily distinguished by its small obtusish leaves not glaucescent beneath and the longer fruit attenuated at the end. The only flower available for examination was still in bud and probably not fully grown; I noticed only 4 anthers in the flower, the upper whorl being apparently lacking. It may prove to be only a small-leaved variety of *W. monnula,* when more material is available. The species is also related to *W. sericea* Domke, but that species is much more densely silky-pubescent and has larger acute leaves.

I have given above a description of this species, since Léveillé (l. c.) merely says: "*Lonicera Vaccinium* Lévl. nov. sp. Habitus, aspectus, folia *Vaccinii myrtillus;* flores Lonicerae, minimi rosei."

Wikstroemia salicina (Lévl.) Léveillé & Blin in Sargent, Pl. Wilson. II. 535 (1916). — Léveillé, Cat. Pl. Yun-Nan, 272 (1917).

Daphne salicina Léveillé in Bull. Geog. Bot. XXV. 42 (1915).

CHINA. Y u n n a n : paturages du Ié-ma-tchouan, 3200 m., *E. E. Maire,* July 1912 (or 1913), "arbuste buissonnant, haut 1.50 m., fl. jaunes" (holotype of *Daphne salicina;* merotype in A. A.).

In his description under *Daphne,* Léveillé gives the date of collecting as 1912, but under *Wikstroemia* he writes 1913.

Daphne tangutica Maximowicz in Mél. Biol. XI. 309 (1881); in Bull. Acad. Sci. St. Pétersb. XXVII. 531 (1882). — Rehder in Jour. Arnold Arb. IX. 97 (1928).

Daphne Bodinieri Léveillé in Bull. Géog. Bot. XXV. 42 (1915); Cat. Pl. Yun-Nan, 271 (1917); non Léveillé (1914). — **Synon. nov.**

Daphne Wilsonii Rehder in Sargent, Pl. Wilson. II. 540 (1916).

CHINA. Y u n n a n : haut plateau de Ta-hai-tse, *E. E. Maire,* May 1912 (holotype of *D. Bodinieri;* photo. in A. A.).

In 1916 Léveillé sent me fragments of the specimen cited above which I identified as *D. Wilsonii;* in consequence, Léveillé crossed out *D. Bodinieri* on his type specimen and labelled it *D. Wilsonii.* The

plant described by Léveillé under the same name the year before is a species of *Melodinus*.

Daphne papyracea Wallich apud Steudel, Nomencl. ed. 2, I. 483 (1841), nomen. — Meisner in Denkschr. Regensb. Bot. Ges. III. 282 (1841). — Rehder in Sargent, Pl. Wilson. II. 546 (1916). — Léveillé, Cat. Pl. Yun-Nan, 272 (1917).

Daphne papyrifera Hamilton ex D. Don, Fl. Nepal. 68 (1825), pro synon. — Léveillé, Fl. Kouy-Tchéou, 416 (1915).

Daphne Mairei Léveillé in Bull. Géog. Bot. xxv. 41 (1915); Cat. Pl. Yun-Nan, 271 (1917). — **Synon. nov.**

Daphne Cavaleriei Léveillé, l. c. 42 (1915); l. c. (1917). — **Synon. nov.**

China. Yunnan: sous bois des montagnes à Ta-tchai, 3000 m., *E. E. Maire,* April 1912, "arbrisseau toujours vert, haut 0.40 m., fl. roses" (holotype of *D. Mairei;* photo. in A. A.); brousse de Lan-ngi-tsin, 2600 m., *E. E. Maire,* March 1912, "arbuste toujours vert, fl. blanches odorantes" (holotype of *D. Cavaleriei;* photo. in A. A.).

As in the case of the preceding species Léveillé sent me in 1916 fragments of *D. Mairei* and *D. Cavaleriei* which I identified as *D. papyracea* and this name was added later by Léveillé to the type specimens of his two species. In his Catalogue des plantes du Yun-Nan, however, he lists both as distinct species and cites *D. Martini* as a synonym of *D. papyracea*.

Daphne Feddei Léveillé in Fedde, Rep. Spec. Nov. IX. 326 (1911); Fl. Kouy-Tchéou, 416 (1915). — Rehder in Sargent, Pl. Wilson. II. 547 (1916).

Daphne Martini Léveillé in Fedde, Rep. Spec. Nov. X. 369 (1912); Fl. Kouy-Tchéou, 416 (1915).

China. Kweichou: without precise locality, *J. Cavalerie,* no. 101 (holotype of *D. Feddei;* photo. in A. A.); environs de Kouy-yang, mont du Collège, *J. Chaffanjon* in hb. E. Bodinier, no. 2076, Feb. 1898 (syntype of *D. Martini;* photo. in A. A.); environs de Gan-pin, grandes rocailles, *L. Martin* in hb. Bodinier, no. 2076, Feb. 1898 (syntype of *D. Martini;* photo. in A. A.); Yeou-lang, *J. Esquirol,* no. 775 (syntype of *D. Martini;* merotype in A. A.).

Bodinier no. 2076 represents a vigorous branch with many additional axillary inflorescences.

Daphne Esquirolii Léveillé in Bull. Géog. Bot. xxv. 42 (1915); Cat. Pl. Yun-Nan, 271 (1917).

Daphne leuconeura Rehder in Sargent, Pl. Wilson. II. 548 (1916).

Daphne leuconeura var. *Mairei* Rehder & Léveillé in Sargent, Pl. Wilson. II. 548 (1916). — Léveillé in Pl. Yun-Nan, 271 (1917).

Wikstroemia leuconeura (Rehd.) Domke in Notizbl. Bot. Gart. Mus. Berlin, XI. 363 (1932).

CHINA. Western Szechuan: Tung River valley, alt. 700 m., *E. H. Wilson,* Veitch Exped. no. 4431, May 1904, "3-4 ft., flowers yellow" (holotype of *D. leuconeura* in A. A.). Yunnan: monts derrière Mongkou, alt. 2000 m., *E. E. Maire,* March 1912 (holotype of *Daphne Esquirolii* and *D. leuconeura* var. *Mairei;* photo. and fragments in A. A.); in dumetis inter flum. Salween et Mekong, alt. 2500-3000 m., *C. Schneider,* no. 2614, Oct. 1914; on boulders and cliffs in the Mekong valley, alt. 4-5000 ft., Lat. 25° 16′ N., *G. Forrest,* no. 13716, April 1917, "shrub of 3-4 ft., flowers light orange yellow"; without precise locality, *G. Forrest,* no. 9895.

When Léveillé sent me a fragment of the specimen cited above with the suggestion that it should be named after E. E. Maire, I did not know of his previous publication of *Daphne Esquirolii* based on the same specimen. I referred it to my new species *D. leuconeura* as a variety, since the very young leaves had a slight pubescence and the whole aspect of the plant was different on account of the precocious flowering in March. All the other specimens cited above were collected later and have fully developed leaves, but Forrest's specimens show below the terminal flowering inflorescence on the same sympodial shoot one or two older inflorescences with the flowers dropped which must have shown when in bloom a condition similar to Maire's specimen having young inflorescences with the lower small leaves scarcely half grown. The slight pubescence of these young leaves probably disappeared later entirely.

Léveillé in his Catalogue des plantes du Yun-nan cites both, *D. Esquirolii* and *D. leuconeura* var. *Mairei,* as valid names.

Stellera chamaejasme Linnaeus, Spec. Pl. 559 (1753).

Stellera Bodinieri Léveillé in Fedde, Rep. Spec. Nov. x. 369 (1912); Fl. Kouy-Tchéou, 417 (1915); Cat. Pl. Yun-Nan, 272 (1917). — **Synon. nov.**

Wikstroemia chamaejasme (L.) Domke in Notizbl. Bot. Gard. Mus. Berlin, XI. 362 (1932).

CHINA. Kweichou: montagnes entre Hin-y-hien et Hin-y-fou, *E. Bodinier,* April 12, 1897, "belles fl. jaunes" (syntype of *S. Bodinieri;* photo. in A. A.). Yunnan: environs de Yun-nan-sen, haut des montagnes, March 19, 1897, montagnes entre Ma-kay et Se-hong, April 9, 1897, *F. Ducloux,* "belles fl. jaunes" (syntypes of *S. Bodinier;* photo. in A. A.).

The three specimens cited by Léveillé under his *S. Bodinieri* differ in the shape of their leaves; Bodinier's specimen has elliptic leaves

about 1 cm. broad, while Ducloux's specimens have narrower leaves, oblanceolate and about 5-6 mm. broad in one and linear and about 2 mm. broad in the other. All three are mounted on the same sheet.

I have here retained *Wikstroemia* and *Stellera* as distinct genera, though Domke gives good reasons for uniting the species of the section *Chamaestellera* and of *Wikstroemia,* while he recommends keeping *Dendrostellera* Van Tiegh. (C. A. Mey. as section of *Stellera*) as a distinct genus. In uniting the two genera Domke places all the species under *Wikstroemia,* because the latter is a nomen conservandum. This, however, is hardly in accordance with art. 46 of the Rules; if Domke's interpretation were correct, then all the species of *Berberis* would have to be transferred to *Mahonia* if the two genera are united, because the latter is a conserved name, and for the same reason, if *Spiraea* and *Sorbaria* should be again united, all the species of *Spiraea* should be transferred to *Sorbaria.* This would nullify the reason for which nomina conservanda were adopted, namely to avoid disadvantageous changes in nomenclature.

LYTHRACEAE

Woodfordia fruticosa (L.) S. Kurz in Jour. As. Soc. Beng. XL.-2, p. 56 (1871). — Koehne in Engler, Pflanzenr. IV.-216, p. 79, fig. 12 (1903). — Handel-Mazzetti, Symb. Sin. VII. 593 (1933).

Lonicera androsaemifolia Léveillé, Fl. Kouy-Tchéou, 62 (1914).

CHINA. K w e i c h o u : Lo-fou, *J. Cavalerie,* no. 3487, March 1909 (holotype of *Lonicera androsaemifolia;* merotype in A. A.).

Lonicera androsaemifolia was first identified with *Woodfordia fruticosa* by Handel-Mazzetti (l. c.).

NYSSACEAE

Nyssa sinensis Oliver in Hooker's Icon. XX. t. 1964 (1891).

Daphniphyllum Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 460 (1911); Fl. Kouy-Tchéou, 161 (1914). — K. Rosenthal in Engler, Pflanzenr. IV.-147a, p. 15 (1919). — **Synon. nov.**

Microrhamnus Bodinieri Léveillé, Fl. Kouy-Tchéou, 341 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Pin-fa, montagnes, *J. Cavalerie,* nos. 2319, 2349, April 26 and May 30, 1905 "arbre de 7 ou 8 m." (syntypes of *Daphniphyllum Cavaleriei,* photos. in A. A.); same locality, *J. Cavalerie,* nos. 1093 and 2381, June 23, 1903 and June 15, 1905 (syntypes of *Microrhamnus Bodinieri;* photo. and merotype in A. A.).

This species has been collected in Kweichou also by Y. Tsiang (no. 5944) at Yunfushan, Tuyun, in 1930.

ALANGIACEAE

Alangium Faberi Oliver in Hooker's Icon. XVIII. t. 1774 (1888). — Léveillé, Cat. Pl. Yun-Nan, 59 (1916). — Melchior in Notizbl. Bot. Gard. Mus. Berlin, X. 823 (1929).

Marlea Bodinieri Léveillé in Bull. Acad. Géog. Bot. XXII. 232 (1912); Fl. Kouy-Tchéou, 116 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Tou-chan, *E. Bodinier* & *J. Cavalerie,* no. 2666, June 27, 1899 (holotype of *Marlea Bodinieri;* photo. in A. A.).

The leaves of *A. Faberi* are almost invariably undivided, but a detached leaf of Bodinier's no. 2666 is deeply three-lobed; the only other specimen in this herbarium with a three-lobed leaf is Wilson's no. 4505.

Alangium Faberi var. **perforatum** (Lévl.), comb. nov.

Ardisia perforata Léveillé in Fedde, Rep. Spec. Nov. IX. 462 (1911); Fl. Kouy-Tchéou, 283 (1914).

CHINA. K w e i c h o u : environs de Gan-pin, dans les grandes rocailles près de la ville, rare, *L. Martin & E. Bodinier,* no. 1632, June 10, 1897, "fl. jaunâtres" (holotype of *Ardisia perforata;* photo. in A. A.).

This variety differs from the type in the much smaller and narrower leaves, 4-7 cm. long and 5-8 mm. broad, rounded to broad-cuneate and nearly equal at the base, more strongly veined beneath and in the rufous pubescence of the branchlets and inflorescence; it seems to be a more compact plant with rather short branchlets. Intermediate forms are R. C. Ching, no. 6337 from Kwangsi, and also judging from Handel-Mazzetti's description (Symb. Sin. VII. 684) Handel-Mazzetti, no. 10516, from Kweichou which I have not seen.

COMBRETACEAE

Combretum Wallichii De Candolle, Prodr. III. 21 (1828). — Exell in Sunyatsenia, I. 87 (1933).

Aspidopterys Cavaleriei Léveillé, Fl. Kouy-Tchéou, 271 (1914), quoad specimina citata; non Léveillé (1911).

Terminalia Mairei Léveillé, Cat. Pl. Yun-Nan, 35 (1915).

CHINA. K w e i c h o u : rochers à 30 kilom. au sud de Tin-fan, *J. Cavalerie,* no. 1882, Sept. 1904 (cited in Fl. Kouy-Tchéou under *Aspidopterys Cavaleriei;* photo. in A. A.); without precise locality, *J. Esquirol,* no. 712 (cited in Fl. Kouy-Tchéou under *Aspidopterys Cavaleriei;* photo. in A. A.). Y u n n a n : montagnes de Pe-long-tsin, 3200 m., *E. E. Maire,* June 1912 (holotype of *Terminalia Mairei;* merotype in A. A.).

Terminalia Mairei was first identified with *C. Wallichii* by Exell (l. c.). As I pointed out under *Aspidopterys Cavaleriei* (Jour. Arnold Arb. XIV. 228) Léveillé cites in his Flore du Kouy-Tchéou the type of *A. Cavaleriei* under *A. Dunniana* and refers to *A. Cavaleriei* two fruiting specimens which do not belong to *Aspidopterys*, but represent *Combretum*.

MYRTACEAE

Decaspermum fruticosum Forster, Char. Gen. 74, t. (1776).

Eugenia Esquirolii Léveillé in Fedde, Rep. Spec. Nov. IX. 459 (1911); Fl. Kouy-Tchéou, 289 (1914). — **Synon. nov.**

Pirus Bodinieri Léveillé, Fl. Kouy-Tchéou, 350 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : hauteur de Lao-ten, *J. Esquirol*, no. 82, June 1904 "grand arbrisseau, fl. roses" (holotype of *Eugenia Esquirolii;* merotype in A. A.); chemin de Lo-hou à Tong-tchéou, *J. Esquirol*, no. 3611, June 10, 1912 (holotype of *Pirus Bodinieri;* merotype in A. A.).

Eugenia Esquirolii and *Pirus Bodinieri* were determined as *Decaspermum fruticosum* by Dr. E. D. Merrill, to whom I had sent specimens for identification. This very widely distributed Malaysian species had not yet been recorded as far north as Kweichou. The only other Chinese specimens we have in this herbarium are all more southern and came from Hainan (Canton Christ. Coll. 8628 and Lingnan Univ. 15772), Kwangtung (Y. Tsiang 2186) and Szemao, S. Yunnan (Rock 2787 and 2832).

MELASTOMACEAE

Melastoma normale D. Don, Prodr. Fl. Nepal. 220 (1825). — Guillaumin in Lecomte, Not. Syst. II. 319 (1913). — Léveillé, Fl. Kouy-Tchéou, 277 (1914); Cat. Pl. Yun-Nan, 176 (1916). — Rehder & Wilson in Sargent, Pl. Wilson. II. 421 (1915).

Melastoma Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. III. 21 (1906).

Melastoma Esquirolii Léveillé, op. cit. VIII. 61 (1910).

CHINA. K w e i c h o u : route de Tchen-lin à Mou-you-se, *J. Cavalerie*, no. 2161, May 25, 1904 "fl. rose pale" (holotype of *M. Cavaleriei;* photo. in A. A.); without precise locality, *J. Esquirol*, no. 873, June 1906, "fl. rouge" (syntype of *M. Esquirolii;* photo. in A. A.); steppes, Hoang-tsao-pa, *J. Esquirol*, no. 1538, June 1909 (syntype of *M. Esquirolii;* photo. in A. A.).

Melastoma Cavaleriei and *M. Esquirolii* were first identified with *M. normale* by Guillaumin (l. c.).

Osbeckia crinita, Bentham apud Wallich, Num. List. no. 4066 (1829), nom. nud. — C. B. Clarke in Hooker f., Fl. Brit. Ind. II. 517

(1879). — Guillaumin in Lecomte, Not. Syst. II. 308 (1913. — Rehder & Wilson in Sargent, Pl. Wilson. II. 422 (1915). — Non Naudin.

Melastoma Mairei Léveillé in Fedde, Rep. Spec. Nov. XI. 300 (1912).

Osbeckia crinita Benth. var. *yunnanensis* Cogniaux in De Candolle, Monog. Phan. VII. 324 (1891). — Léveillé, Fl. Kouy-Tchéou, 277 (1914); Cat. Pl. Yun-Nan, 176 (1916).

CHINA. Yunnan: Tchouan-se-pa, 650 m., vallées et collines herbeuses, *E. E. Maire,* June 1911, "fl. rouges, grandes" (holotype of *Melastoma Mairei;* photo. in A. A.).

Melastoma Mairei was first identified with *Osbeckia crinita* by Guillaumin (l. c.) who groups the Chinese plants under var. *yunnanensis,* but Handel-Mazzetti (Symb. Sin. VII. 597) says and I agree that there is no difference between the Indian and the Chinese plants.

Plagiopetalum Esquirolii (Lévl.), comb. nov.

Sonerila Esquirolii Léveillé in Bull. Soc. Bot. France, LIV. 368 (1907); in Fedde, Rep. Spec. Nov. XI. 494 (1913).

Barthea Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. VIII. 61 (1910), pro parte, quoad Esquirol no. 215.

Barthea Blinii Léveillé in Fedde, Rep. Spec. Nov. XI. 494 (1913).

Allomorphia Blinii (Lévl.) Guillaumin in Bull. Soc. Bot. France, LX. 87 (1913). — Léveillé, Fl. Kouy-Tchéou 276, (1914).

Plagiopetalum quadrangulum Rehder in Sargent, Pl. Wilson. III. 453 (1917).

Plagiopetalum serratum (Diels) Diels in Bot. Jahrb. LXV. 100 (1932).

CHINA. Kweichou: Hoa-ouan-yao, *J. Esquirol,* no. 645, Aug. 1905 (holotype of *Sonerila Esquirolii* of 1907; ex Léveillé et ex Diels); without precise locality, *J. Esquirol,* no. 644, in 1906 (holotype of *S. Esquirolii* of 1913 ex Léveillé et ex Guillaumin); anfractuosités du pic de Ko-tchang-kéou, *J. Esquirol,* no. 215, Sept. 1904 "pied unique" (syntype of *Barthea Cavaleriei* and holotype of *Barthea Blinii;* photo. in A. A.).

I have not seen the types of the two specimens described independently as *Sonerila Esquirolii,* each name being based on a different type. Guillaumin (l. c.) cites only no. 644, the type of the *Sonerila Esquirolii* of 1913, but Diels (l. c.) cites both, 644 and also 645, the type of the *Sonerila Esquirolii* of 1907, which shows that the two are conspecific. Also Léveillé in Flore du Kouy-Tchéou cites both specimens under *Allomorphia Blinii.* Diels apparently overlooked the earlier publication and therefore based his new combination on his *Oxyspora serrata* of 1912.

Oxyspora paniculata De Candolle, Prodr. III. 123 (1828). — Léveillé, Cat. Pl. Yun-Nan, 176 (1916). — Diels in Bot. Jahrb. LXV. 104 (1932).

Bredia soneriloides Léveillé in Fedde, Rep. Spec. Nov. IX. 21 (1910). *Sonerila Cavaleriei* Léveillé in herb., l. c. (1910), pro synon. *Brediae soneriloidis;* XI. 494 (1913).

CHINA. Kweichou: Lo-fou, *J. Cavalerie,* no. 3645, Oct. 1908 (holotype of *Bredia soneriloides;* ex Léveillé et ex Diels); près de chemin entre Pien-yang et Lo-fou, *J. Cavalerie,* no. 2681 (holotype of *Sonerila Cavaleriei;* ex Léveillé et ex Diels).

Bredia soneriloides and *Sonerila Cavaleriei* have been identified with *Oxyspora paniculata* by Diels (l. c.). Léveillé in 1910 quotes *Sonerila Cavaleriei* as a synonym of *Bredia soneriloides,* but in 1913 he describes it as a distinct species based on a different specimen, though the description reveals no characters to distinguish it from *Bredia soneriloides.* I have not seen the specimens cited above.

Blastus cochinchinensis Loureiro, Fl. Cochinch. 526 (1790). — Guillaumin in Bull. Soc. Bot. France, LX. 89 (1913). — Léveillé, Fl. Kouy-Tchéou, 276 (1914). — Diels in Bot. Jahrb. LXV. 105 (1932).

Blastus Marchandii Léveillé in Fedde, Rep. Spec. Nov. XI. 494 (1913).

CHINA. Kweichou: Tchang-loy, *J. Esquirol,* no. 967, June 1906 "arbrisseau, 3 m. hauteur, fleur rouge" (holotype of *B. Marchandii;* photo. in A. A.).

Blastus Marchandii was first identified with *B. cochinchinensis* by Guillaumin and this identification was adopted by Léveillé in his Flore du Kouy-Tchéou.

Blastus pauciflorus (Benth.) Guillaumin in Bull. Soc. Bot. France, LX. 90 (1913). — Léveillé, Fl. Kouy-Tchéou, 276 (1914). — Diels in Bot. Jahrb. LXV. 107 (1932).

Blastus Cavaleriei Léveillé & Vaniot in Mém. Soc. Nat. Sci. Nat. Cherbourg, XXXV. 395 (1906); in Fedde, Rep. Spec. Nov. IV. 94 (1907).

Allomorphia Bodinieri Léveillé in Fedde, Rep. Spec. Nov. V. 100 (1908).

Bredia Bodinieri Léveillé, l. c. (1908), pro synon.

CHINA. Kweichou: environs de Tou-chan, *J. Cavalerie* in hb. Bodinier, no. 2676, June 27, 1899, "arbrisseau, fl. roses" (holotype of *B. Cavaleriei* and of *Allomorphia Bodinieri;* photo. in A. A.).

Blastus Cavaleriei was first identified with *B. pauciflorus* by Guillaumin and cited by Léveillé in his Flore du Kouy-Tchéou under the latter name; both cite an additional number, 2170, from the same locality.

Blastus Dunnianus Léveillé in Fedde, Rep. Spec. Nov. IX. 449 (1911); Fl. Kouy-Tchéou, 276 (1914). — Guillaumin in Bull. Soc. Bot. France, LX. 91 (1913). — Diels in Bot. Jahrb. LXV. 107 (1932).

CHINA. Kweichou: Ma-jo, rare, *J. Cavalerie*, no. 2971, July 1908, "arbrisseau, 1 à 2 m., fl. roses" (holotype; merotype in A. A.).

Notes on herbaceous Melastomaceae described by Léveillé and critically examined by Guillaumin and by Diels, of which I have seen no specimens, may be appended here.

Bredia Cavaleriei (Lévl.) Diels in Bot. Jahrb. LXV. 110 (1932). — Handel-Mazzetti, Symb. Sin. VII. 599 (1933).

Barthea Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. VIII. 61 (1910), quoad specimen Cavalerie, no. 1552.

Fordiophyton Cavaleriei (Lévl.) Guillaumin in Bull. Soc. Bot. France, LX. 275 (1913), quoad typum. — Léveillé, Fl. Kouy-Tchéou, 276 (1914), quoad typum.

Fordiophyton Cavaleriei var. *violacea* Léveillé, Cat. Pl. Yun-Nan, 176 (1916), nom. nud.

CHINA. Kweichou: *Cavalerie*, no. 1552 (holotype of *Barthea Cavaleriei;* ex Léveillé, Guillaumin, Diels).

Guillaumin mentions as probably belonging here *Barthea Esquirolii* Léveillé, Fl. Kouy-Tchéou, 276. 1914, pro synon. (*B. Cavaleriei* Léveillé in Fedde, Rep. Spec. Nov. VIII. 61. 1910; pro parte, quoad specim. Esquirol, no. 1581), but Diels says that the specimen is too incomplete to be determined.

Bredia yunnanensis (Lévl.) Diels in Bot. Jahrb. LXV. 111 (1932).

Blastus yunnanensis Léveillé in Fedde, Rep. Spec. Nov. XI. 300 (1912).

Blastus Mairei Léveillé, l. c. (1912).

Fordiophyton Cavaleriei (Lévl.) Guillaumin in Bull. Soc. Bot. France, LX. 275 (1913), pro parte, quoad specim. e Yunnan.

CHINA. Yunnan: Long-ky, *E. E. Maire*, Aug. 1911 (holotype of *Blastus yunnanensis;* ex Léveillé, Guillaumin, Diels); same locality, *E. E. Maire*, June 1911 (holotype of *Blastus Mairei;* ex Léveillé, Guillaumin).

Diels (l. c.) expresses doubt that *B. Mairei* belongs here.

Fordiophyton Faberi Stapf in Ann. Bot. VI. 314 (1892). — Guillaumin in Bull. Soc. Bot. France, LX. 274 (1913). — Léveillé in Fl. Kouy-Tchéou, 276, (1914). — Diels in Bot. Jahrb. LXV. 114 (1932).

Bredia Cavaleriei Léveillé & Vaniot in Mém. Soc. Nat. Sci. Nat. Cherbourg, XXXV. 396 (1906); in Fedde, Rep. Spec. Nov. IV. 94 (1907).

Oxyspora Cavalerici Léveillé in herb., l. c. (1906) and (1907), pro synon. *Brediae Cavaleriei.*

Bredia Mairei Léveillé in Fedde, Rep. Spec. Nov. XI. 300 (1912).

Blastus Lyi Léveillé, l. c. 301 (1912).

CHINA. Kweichou: Tou-chan, *J. Cavalerie* (holotype of

Bredia Cavaleriei; ex Léveillé, Guillaumin); Pin-fa à Tou-yun, *J. Cavalerie*, no. 2977 (holotype of *Blastus Lyi*, ex Léveillé, Guillaumin). Yunnan: Long-ky, *E. E. Maire*, June 1911 (holotype of *Blastus Mairei;* ex Léveillé, Guillaumin).

Phyllagathis Cavaleriei (Lévl. & Vant.) Guillaumin in Bull. Soc. Bot. France, LX. 273 (1913).—Léveillé, Fl. Kouy-Tchéou, 277 (1914). — Diels in Bot. Jahrb. LXV. 115 (1932).

Allomorphia Cavaleriei Léveillé & Vaniot in Mém. Soc. Nat. Cherbourg, XXXV. 394 (1906); in Fedde, Rep. Spec. Nov. IV. 94 (1907).

Oxyspora Cavaleriei Léveillé in herb., l. c. (1906 and 1907), pro synon. *Allomorphiae Cavaleriei.*

CHINA. Kweichou: *J. Cavalerie*, no. 2675 (syntype of *Allomorphia Cavaleriei;* ex Léveillé, Diels); *J. Cavalerie*, no. 56 (syntype of *A. Cavaleriei*, ex Léveillé, Guillaumin); *J. Cavalerie*, no. 246 (syntype of *A. Cavaleriei;* ex Léveillé, Diels).

ARALIACEAE

Trevisia palmata (Roxb.) Visiani in Mem. Accad. Torin. ser. 2, IV. 262, pl. (1842). — Léveillé, Cat. Pl. Yun-Nan, 11 (1915).

Fatsia Cavaleriei Léveillé in Bull. Géog. Bot. XXIV. 144 (1914); Fl. Kouy-Tchéou, 34 (1914). — **Synon. nov.**

CHINA. Kweichou: Houa-kiang, *J. Cavalerie*, no. 2144, June 6, 1904, "h. 3 m." (holotype of *Fatsia Cavaleriei;* photo. in A. A.).

Tetrapanax papyrifera (Hook.) K. Koch in Wochenschr. Gaertn. Pflanzenk. II. 371 (1859).

Fatsia papyrifera (Hook.) Nicholson, Ill. Dict. Gard. II. 3 (1887). — Léveillé, Fl. Kouy-Tchéou, 34 (1914); Cat. Pl. Yun-Nan, 11 (1915).

Aralia Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 342 (1914); Fl. Kouy-Tchéou, 34 (1914); Cat. Pl. Yun-Nan, 11 (1915). — **Synon. nov.**

CHINA. Kweichou: Ting-tsao, *J. Esquirol*, no. 678 (cited in Fl. Kouy-Tchéou under *Aralia Mairei;* ex Léveillé). Yunnan: vallée de Lin-kiang-ki, 700 m., *E. E. Maire*, Nov. 1913, "arbuste poreux à tronc denudé, haut 1.50 m., feuilles terminales, tomenteuses, blanches en dessous, fl. grises, faisceaux de grappes dressés" (holotype of *A. Mairei;* merotype in A. A.).

Schefflera Delavayi (Franch.) Harms in Bot. Jahrb. XXIX. 486 (1900).

Heptapleurum Delavayi Franchet in Jour. de Bot. X. 307 (1896). — Léveillé, Cat. Pl. Yun-Nan, 11 (1915).

Heptapleurum Dunnianum Léveillé in Fedde, Rep. Spec. Nov. XI. 295 (1912); Fl. Kouy-Tchéou, 35 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Kouy-yang, dans la montagne près du Collège, *E. Bodinier,* no. 2506, Sept. 1898 (holotype of *H. Dunnianum;* photo. in A. A.).

Léveillé compares his *Heptapleurum Dunnianum* with *H. Delavayi* Franch. and says it differs from it in "foliis dimorphis usque 7-foliolatis membranaceis nec lucidis," but all these characters apply as well to *H. Delavayi.*

Schefflera Bodinieri (Lévl.) Rehder in Jour. Arnold Arb. XI. 166 (1930).

Heptapleurum Bodinieri Léveillé in Fedde, Bull. Géog. Bot. XXIV. 144 (1914); Fl. Kouy-Tchéou, 35 (1914).

CHINA. K w e i c h o u : district de Tsin-gay, vallée de Kia-la-tchang, *J. Laborde* in herb. Bodinier, no. 2459, Dec. 21, 1897, "grand arbuste" (syntype; merotype in A. A.); environs de Kouy-yang, mont du Collège, *E. Bodinier,* Feb. 17 and Sept. 1898 (syntypes; ex Léveillé); route de Pin-fa à Kouy-tin, *J. Cavalerie,* no. 3098 in part, Dec. 4, 1902 (syntype; ex Léveillé); Long-ly, *J. Cavalerie,* nos. 1567 and 3098 in part, Sept. 1907 (cited in Fl. Kouy-Tchéou; duplicate of no. 1567 and photo. of no. 3098 in A. A.).

Schefflera elliptica (Bl.) Harms in Engler & Prantl, Nat. Pflanzenfam. III.-8, p. 39 (1894).

Heptapleurum Cavalerici Léveillé in Fedde, Rep. Spec. Nov. IX. 326 (1911); Fl. Kouy-Tchéou, 35 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : ouest de Lo-fou, rivière de Pia-nai, *J. Cavalerie,* no. 2658, Nov. 5, 1905, "petit arbre" (holotype of *Heptapleurum Cavaleriei;* photo. in A. A.).

Cavalerie's no. 2658 has the leaves somewhat less prominently reticulate than most of the specimens before me, but in all other characters the specimen which is in fruit agrees well with the Chinese, Indian and Malaysian material before me. I am unable to see any constant characters to separate *S. elliptica* from *S. venulosa* (Wight & Arn.) Harms and follow C. B. Clarke, Viguier and Handel-Mazzetti in uniting the two.

Schefflera spec.

Acanthopanax Esquirolii Léveillé in Bull. Géog. Bot. XXIV. 143 (1914); Fl. Kouy-Tchéou, 33 (1914).

CHINA. K w e i c h o u : district de Tin-fan, *J. Cavalerie,* 1847 bis, Nov. 1914 (holotype of *Acanthopanax Esquirolii;* merotype in A. A.).

Acanthopanax Esquirolii seems to be related to *S. octophylla* (Lour.) Harms, but is readily distinguished by the remotely serrulate leaflets.

The slender-pedicelled flowers are borne in many flowered long-peduncled umbels which seem to form large panicles; the inflorescence is sparingly stellate-pubescent; the style is about one mm. long. It may be a new species, but the material is too fragmentary for a satisfactory description.

Schefflera spec.

Eleutherococcus Bodinieri Léveillé in Bull. Géog. Bot. XXIV. 144 (1914); Fl. Kouy-Tchéou, 33 (1914).

CHINA. Kweichou: district de Tsin-gay, vallée de Kia-la-tchang, *J. Laborde* in hb. Bodinier, Dec. 21, 1897, "grand arbuste" (holotype of *Eleutherococcus Bodinieri;* photo. in A. A.).

Eleutherococcus Bodinieri apparently belongs to *Schefflera* and may be related to *S. Bodinieri* (Lévl.) Rehd., but the leaves are 3—6-foliolate and the leaflets are elliptic to oblong; the broader leaflets are mostly remotely and rather coarsely dentate toward the apex, while the narrower ones are entire. It may be a new species, but as I have only a photograph and not the original specimen before me, I have to leave the question open.

Brassaiopsis ciliata Dunn in Jour. Linn. Soc. Bot. XXXV. 499 (1903).

Acanthopanax Bodinieri Léveillé in Bull. Géog. Bot. XXIV. 143 (1914); Fl. Kouy-Tchéou, 33 (1914). — **Synon. nov.**

CHINA. Kweichou: environs de Gan-pin, plante rare, pousse dans le fond d'une profonde depression sombre et humide en forme de Tong, *L. Martin* in hb. Bodinier, no. 1928, Oct. 24, 1897, "tige sous-ligneuse, de 1 m. de haut, fl. blanches" (holotype of *Acanthopanax Bodinieri;* photo. in A. A.).

Brassaiopsis tripteris (Lévl.), comb. nov.

Heptapleurum tripteris Léveillé in Bull. Géog. Bot. XXIV. 145 (1914); Fl. Kouy-Tchéou, 35 (1914); Cat. Ill. Pl. Seu-Tchouen, pl. 1 (1918) MS.

CHINA. Kweichou: ouest de Lo-fou, bois, *J. Cavalerie,* no. 2566, Nov. 1905 (holotype of *Heptapleurum tripteris;* merotype in A. A.).

Brassiopsis tripteris is a very distinct species. In habit it resembles *B. ficifolia* Dunn, but is even lower; the leaves are tripartite to the base, or sometimes as in the specimen before me with an additional small basal lobe, and are conspicuously spinose-serrulate, the leaflets ending into a long slender acumen not shown in the figure cited above.

Nothopanax Delavayi (Franch.) Harms in Bot. Jahrb. XXIX. 488 (1900).

Panax Delavayi Franchet in Jour. de Bot. x. 305 (1896). — Léveillé, Cat. Pl. Yun-Nan, 11 (1915).

Aralia Bodinieri Léveillé in Bull. Géog. Bot. XXIV. 143 (1914); Fl. Kouy-Tchéou, 34 (1914). — **Synon. nov.**

Heptapleurum Esquirolii Léveillé, l. c., 145 (1914); l. c. 35 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Gan-pin, dans les rocailles, *L. Martin* in hb. Bodinier, no. 2696, Aug. 2, 1897, "petit arbuste, fl. blanches" (syntype of *Aralia Bodinieri;* photo. in A. A.); same locality and same collector, no. 2696 in part, Aug. 27, 1899 (syntype of *Aralia Bodinieri,* ex Léveillé); Pin-fa, *J. Cavalerie,* no. 871, Feb. 17, 1905, "fruit noir" (holotype of *Heptapleurum Esquirolii,* photo. in A. A.).

Aralia chinensis L. var. **nuda** Nakai in Jour. Arnold Arb. v. 32 (1924).

Eleutherococcus Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 342 (1914); Cat. Pl. Yun-Nan, 11 (1915). — **Synon. nov.**

CHINA. Y u n n a n : brousse des montagnes à Pe-long-tsin, alt. 3200 m., *E. E. Maire,* Nov. 1913, "petit arbre moelleux, haut 3-4 m., feuilles pennées, en panache au sommet" (holotype of *Eleutherococcus Mairei;* merotype in A. A.).

Maire's specimen consists only of an inflorescence with flowers and immature fruits, about 35 cm. long and 11 cm. wide; it agrees exactly with *A. chinensis* and the rather slight pubescence indicates var. *nuda.*

CORNACEAE

Cornus oblonga Wallich in Roxburgh, Fl. Ind. I. 432 (1920). — Léveillé, Cat. Pl. Yun-Nan, 59 (1916).

Ardisia discolor Léveillé in Fedde, Rep. Spec. Nov. x. 373 (1912); Fl. Kouy-Tchéou, 283 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Ma-jo, *J. Cavalerie,* no. 3610 (holotype of *Ardisia discolor;* merotype in A. A.).

Cornus Monbeigii Hemsley in Kew Bull. Misc. Inform. 1909, p. 333, "Mombeigii."

Cornus rosea Léveillé in Bull. Géog. Bot. XXIV. 288 (1914); Cat. Pl. Yun-Nan, 59 (1916). — **Synon. nov.**

CHINA. Y u n n a n : paturages du plateau de Je-ma-tchouan, 3200 m., *E. E. Maire,* July 1912 (holotype of *C. rosea;* merotype in A. A.).

Cornus macrophylla Wallich in Roxburgh, Fl. Ind. I. 433 (1820); — Léveillé, Fl. Kouy-Tchéou, 116 (1914); Cat. Pl. Yun-Nan, 59 (1916).

Cornus Bodinieri Léveillé, Fl. Kouy-Tchéou, 116 (1914), pro synon. *C. macrophyllae.*

China. Kweichou: environs de Kouy-yang, bois de la pagode Kien-lin-chan, *E. Bodinier,* no. 1587 in part, April 14, 1898 (holotype of *C. Bodinieri;* photo. in A. A.); près du College, a Lan-tsong, *E. Bodinier,* no. 1587 in part, May 7, 1897.

The name *Cornus Bodinieri* is quoted only as a synonym of *C. macrophylla* (l. c.), though the labels of the two specimens cited above bear the name *Cornus Bodinieri* and not that of *C. macrophylla.* In the Flore du Kouy-Tchéou only the specimen from Kouy-yang is cited. Bodinier gives on the label of this specimen the following description of the habit of the tree and states that it is called in Chinese San chou = Arbre-parapluie: "Cet abre, qq. fois très grand, pousse d'abord un premier étage de branches partant à peu près de même point et s'étendant horizontalement comme un paraplue, plus haut, un second étage de branches, puis un troisième, puis une tête droite."

Cornus paucinervis Hance in Jour. Bot. xix. 217 (1881). — Léveillé, Fl. Kouy-Tchéou, 116 (1915); Cat. Pl. Yun-Nan, 59 (1916).

Cornus Amblardi Léveillé in Bull. Soc. Bot. France, li. cxliv. (1904); Fl. Kouy-Tchéou, 115 (1914); Cat. Pl. Yun-Nan, 59 (1916). — **Synon. nov.**

China. Kouy-Tchéou: Pin-fa, bords des ruisseaux, *J. Cavalerie,* no. 80, May 30 and July 21, 1902, "hauteur moyenne 1 m., fl. blanches" (holotype of *C. Amblardi;* photo. in A. A.); Kouy-yang, mont du Collège, à la Cascade, *E. Bodinier,* no. 2317, May 28, 1898, "arbuste, belles fleurs blanches" (cited in Fl. Kouy-Tchéou under *C. Amblardi;* duplicate in A. A.).

Cornus canadensis Linnaeus, Spec. Pl. 118 (1753).

Cornus Fauriei Léveillé in Fedde, Rep. Spec. Nov. viii. 281 (1910). — **Synon. nov.**

Saghalin: in silvis Soriofka, *U. Faurie,* no. 762, Sept. 2, 1908 (holotype of *C. Fauriei;* photo. in A. A.).

Cornus capitata Wall. var. **mollis** Rehder in Sargent, Pl. Wilson. ii. 579 (1916, March).

?Cornus capitata var.*hypoleuca* Léveillé, Cat. Pl. Yun-Nan, 59 (1916, May).

China. Yunnan: mi-mont du Io-chan, 3300 m., *E. E. Maire,* June 1912 (holotype of *C. capitata* var. ***hypoleuca;*** ex Léveillé).

I have not seen the type of *C. capitata* var. ***hypoleuca,*** but according to Léveillé's description it is probably the same as my *C. capitata* var. *mollis* which was based on Hupeh specimens.

(To be continued)

Herbarium Arnold Arboretum,
Harvard University.

STUDIES IN THE GENUS FRAXINUS

I. A PRELIMINARY KEY TO WINTER TWIGS FOR THE SECTIONS MELIOIDES AND BUMELIOIDES.

C. M. WHELDEN

With plates 87-89 and two text figures

THIS STUDY represents a preliminary attempt to provide a key for the identification of certain species of *Fraxinus* in the winter condition. The key is a preliminary one in two respects. In the first place, it is limited to those species of the sections Melioides and Bumelioides of which living material was available for study. In the second place, like any key based entirely on dormant twigs, it needs extensive checking in the field. For this reason, the author will be grateful if those who use the key and the descriptions will bring any inaccuracies to his attention.

Wherever possible collections were made at several localities, and from many trees. In the case of exotic species grown only at the Arnold Arboretum, it was often necessary to limit the study to one or two trees, supplementing the information thus gathered with such evidence as could be obtained from herbarium material.

The following species and varieties were included in the study. The numbers in parenthesis refer to the number of localities at which collections were made, exclusive of herbarium material.

SECTION MELIOIDES

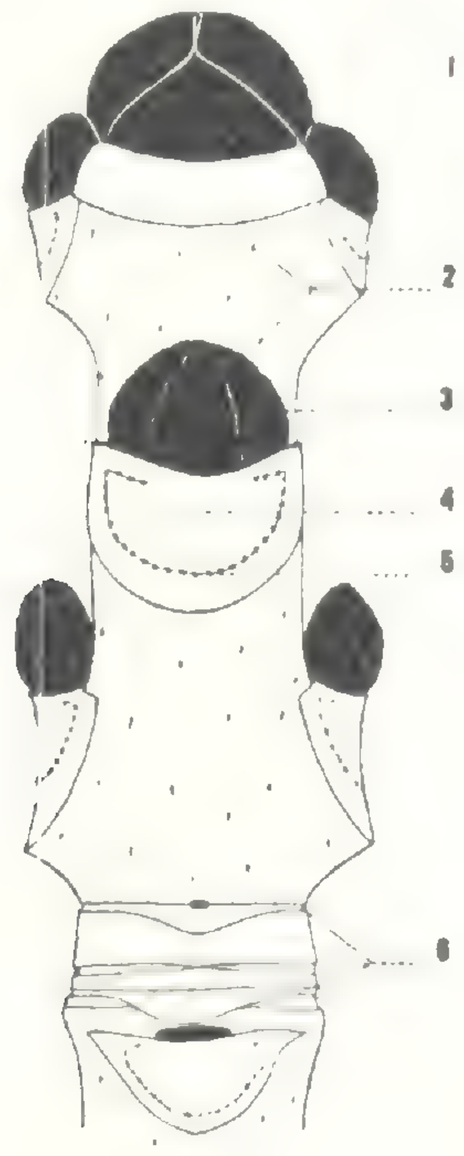
Fraxinus pennsylvanica Marsh. (3).
" biltmoreana Beadle (2).
" profunda Bush (2).
" oregona Nutt. (1).
" pennsylvanica var. lanceolata Sarg. (3).
" americana L. (7).
" texensis Sarg. (1).

SECTION BUMELIOIDES

Fraxinus syriaca Boiss. (1).
" potamophila Herd. (1).
" quadrangulata Michx. (3).
" mandshurica Rupr. (1).
" holotricha Koehne (1).
" oxycarpa Willd. (1).
" excelsior L. (1).
" nigra Marsh. (4).

A twig of *Fraxinus* in the winter condition (Fig. 1) presents a number of features of diagnostic value: terminal bud, terminal bud scales, terminal bud scale scars, lateral buds, leaf scars, bundle scars, lenticels, bark, pubescence.

TERMINAL BUD: The terminal bud varies in shape from obtuse as in *F. americana* to acute as in *F. biltmoreana*. The terminal bud is of a brown color which ranges from nearly black in *F. excelsior* to a light rusty brown in *F. pennsylvanica*. In all cases, except that of *F. nigra*, the terminal bud is closely flanked by a pair of lateral buds. In *F. nigra* the terminal bud is solitary, that is, it is raised above the distal pair of laterals.



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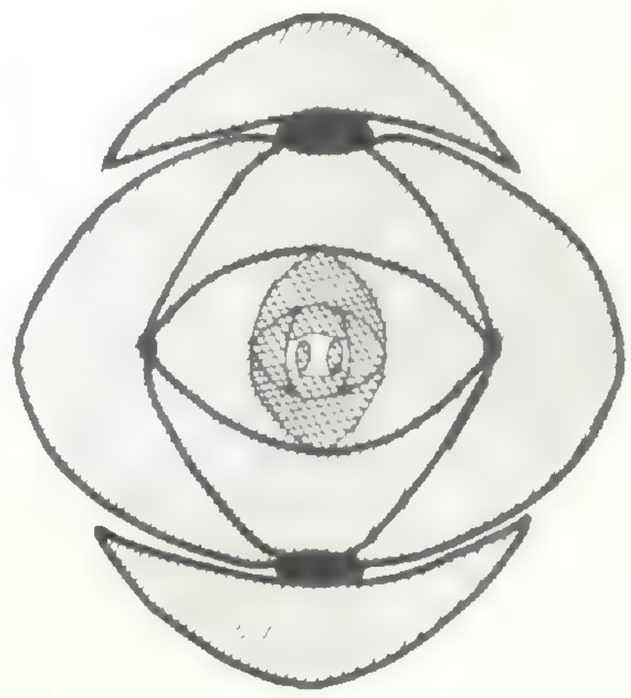

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FIGURE 1. Dormant twig of FRAXINUS (somewhat diagrammatic). 1, terminal bud; 2, lenticels; 3, lateral bud; 4, leaf scar; 5, bundle scars; 6, terminal bud scale scars.

FIGURE 2. Cross section of a terminal bud of FRAXINUS. Bud scales are shaded with diagonal lines, leaves are cross hatched.

TERMINAL BUD SCALES: The number of terminal bud scales varies from two to four pairs, although it is generally consistent within a given species. The scales are arranged decussately as shown in Fig. 2. The individual scales vary in shape from ovate, apiculate, flat, to lanceolate, pinnate, and thickened on the back. They also may be tightly appressed (*F. americana*) or loose (*F. mandshurica*). A character of considerable systematic importance is the development of the foliar tip of the terminal bud scales. Though it is subject to considerable variation within the species, it remains as one of the best

guides to winter identification. The terminal bud scales are always pubescent, varying somewhat in degree. In *F. quadrangulata,* they are hoary tomentose, while at the other extreme are such species as *F. americana* and *F. texensis* in which the pubescence is reduced to a minute scurfy puberulence. The inner scales of *F. syriaca* are hoary tomentose and protrude from beneath the outer scales. The outer scales of *F. biltmoreana* are wooly along their midrib.

TERMINAL BUD SCALE SCARS: The number of terminal bud scales can be more readily obtained from the scars than from the bud itself. This number is a valuable aid in the identification of the species. For example, *F. americana* has four pairs; *F. nigra* and *F. quadrangulata* have three pairs; while *F. oxycarpa* has two pairs.

LATERAL BUDS: The number of leaf pairs per year varies from three or even two pairs to as high as twelve pairs. Ordinarily they are arranged oppositely except in *F. syriaca* where they are usually whorled. The whorled arrangement may occur in any of the species. It was found occasionally in *F. potamophila* and *F. oxycarpa,* and in a single specimen of *F. americana.*

The lateral buds of *Fraxinus* may be divergent or convergent; angular or rounded. Divergent buds are those which stand at a sharp angle to the twig rather than being closely pressed and nearly parallel with it. Angular buds are those which tend to be diamond shaped rather than circular in cross section.

LEAF SCARS: The leaf scars range from semiorbicular or crescent shaped (*F. americana*) to semicircular (*F. pennsylvanica*) to oblong or obconic (*F. profunda*) to orbicular (*F. nigra*) to obcordate (*F. biltmoreana*). The leaf scars may be raised from the surface of the twig as in *F. mandshurica* or flat as in *F. pennsylvanica.*

The upper edge of the leaf scar protrudes, forming a shelf which sheathes in varying degree the base of its lateral bud in the following species; *F. oxycarpa, F. nigra, F. pennsylvanica, F. pennsylvanica var. lanceolata, F. excelsior, F. oregona, F. profunda, F. quadrangulata, F. mandshurica, F. holotricha, F. biltmoreana* and *F. texensis.* This feature reaches its maximum development in *F. nigra.* Pubescence appears on the extreme upper edge of this shelf in the following species; *F. pennsylvanica var. lanceolata, F. biltmoreana, F. holotricha* and *F. mandshurica.* Generally the surface of the scar is flat, but the conspicuous shelf in *F. nigra* gives it a concave appearance while the raised bundle scars of *F. profunda* make the scar appear convex.

The leaf scars of *F. pennsylvanica* and *F. oregona* are often a darker color below the bundle scars than above them. That is, the lower portion may be greenish grey (*F. oregona*) or dull brick-red (*F.*

pennsylvanica). The upper part of the scar is always a dull light buff.

The angle which the leaf scar makes with the twig is from 45° (*F. americana*) to nearly parallel with the twig surface (*F. nigra*).

BUNDLE SCARS: The bundle scars of *Fraxinus* are confluent, forming a slightly raised line above the surface of the leaf scar. This is often very pronounced in *F. profunda*. The line parallels the margin of the leaf scar, even turning in at its upper edge. The relative position of the line varies, that is, it is nearer the margin than the center of the leaf scar in *F. americana* while in *F. quadrangulata* this condition is reversed. Due to the confluence of the bundle scars it is difficult to ascertain their number which seems to vary from twenty to thirty in each leaf scar.

LENTICELS: In all the species of *Fraxinus* examined, the lenticels are conspicuous, more or less elongated, light colored dots. They are scattered over the twig except in *F. quadrangulata* where often they tend to be grouped beneath the leaf scar.

BARK: The outer bark of the twigs is of little diagnostic value. The bark of *F. oregona* has a greenish hue beneath the pubescence, whereas that of *F. americana* is dark shiny maroon often splotched with a glaucus bloom.

The inner bark in the Melioides section is shiny brick-red while that of the Bumelioides section is dull light buff except in the case of *F. oregona* which resembles the Melioides section. The internodes of *F. quadrangulata* are more or less four-angled due to the development of corky ridges.

PUBESCENCE: The degree of pubescence varies from completely glabrous (*F. americana*) to tomentose (*F. biltmoreana*). The pubescence of *F. pennsylvanica* may persist for two or three seasons or disappear after the first summer, while that of *F. biltmoreana* usually does not persist after the first summer.

The pubescence of *F. quadrangulata* and *F. oregona* is more dense at the nodes than at any other part of the twig. The twig of *F. nigra* is glabrous except just below the terminal bud where there are many small dots of scurfy-pubescence.

KEY TO SECTIONS

A. Terminal bud scales entire; inner bark brick-red (except in *F. oregona*) ..... MELIOIDES

AA. Terminal bud scales foliar; inner bark light buff.... BUMELIOIDES

Section MELIOIDES

A. Branchlets pubescent.

B. Twigs tomentose throughout; buds light brown.

C. Diameter of terminal bud conspicuously smaller than that of twig; upper edge of leaf scars not lined with hairs. .....1. *F. pennsylvanica*

CC. Diameter of terminal bud equal to or larger than that of twig; upper edge of leaf scars lined with hairs .....2. *F. biltmoreana*

BB. Twigs unevenly tomentose; buds dark brown.

C. Terminal bud scales usually in three pairs; outer terminal bud scales usually sharply truncate. 3. *F. profunda*

CC. Terminal bud scales usually in four pairs; outer terminal bud scales not truncate. .....4. *F. oregona*

AA. Branchlets glabrous.

B. Terminal bud acute. ....5. *F. pennsylvanica var. lanceolata*

BB. Terminal bud obtuse.

C. Terminal bud scales usually in four pairs; base of lateral buds not sheathed. .....6. *F. americana*

CC. Terminal bud scales usually in three pairs; base of lateral buds sheathed. .....7. *F. texensis*

Section BUMELIOIDES

A. Twigs shiny green; lateral buds keeled, not sheathed at base.

B. Inner lateral bud scales visible, light wooly pubescent; upper edge of leaf scars protruding; bundle scars above center of leaf scar; leaves always whorled. .....8. *F. syriaca*

BB. Inner lateral bud scales not visible; upper edge of leaf scars not protruding; bundle scars bisecting leaf scar; leaves seldom whorled. .....9. *F. potamophila*

AA. Twigs not shiny green; lateral buds not keeled, sheathed at base.

B. Twigs with more or less quadrangular internodes.

C. Lenticels often grouped below leaf scars; lower edge of leafs scars often flattened; twigs short rufous to scurfy-pubescent; buds wooly-pubescent. 10. *F. quadrangulata*

CC. Lenticels scattered; lower edge of leaf scars rounded: twigs glabrous; buds scurfy-pubescent. 11. *F. mandshurica*

BB. Twigs with rounded internodes.

C. Twigs pubescent; terminal bud scales usually in three pairs. .....12. *F. holotricha*

CC. Twigs glabrous; terminal bud scales usually in two or three pairs.

D. Terminal bud scales in two pairs; twigs flattened at nodes .....13. *F. oxycarpa*

DD. Terminal bud scales usually in three pairs; twigs rounded at nodes.

E. Terminal bud flanked, obtuse; upper edge of leaf scars protruding slightly. .....14. *F. excelsior*

EE. Terminal bud solitary, acute; upper edge of leaf scars protruding sharply. .....15. *F. nigra*

DESCRIPTION OF SPECIES

1. **Fraxinus pennsylvanica** Marsh. Plate 87, Fig. 1.

Terminal bud acute, flanked or nearly so; three pairs of scales, outer pair truncate, rufous-tomentose, usually rusty-brown. Lateral buds rounded. Leaf scars semicircular, parallel with twig or nearly so, upper edge protruding slightly. Twigs stout, tomentose, pubescence often persisting through third season. Portion of leaf scar below bundle scars sometimes dull red. Bark of twig immediately below leaf scar often brick-red. Inner bark shiny brick-red.

2. **Fraxinus biltmoreana** Beadle. Plate 87, Fig. 2.

Terminal bud apiculate, usually broader than long, flanked; three pairs of keeled scales, villose, light rusty-brown to dark brown, outer pair shorter than inner and often truncate. Lateral buds rounded, scurfy-pubescent. Leaf scars obcordate to semicircular, at thirty to forty-five degree angle with twig, upper edge hirsute, protruding slightly. Twigs stout, tomentose. Inner bark shiny brick-red.

3. **Fraxinus profunda** Bush. Plate 87, Fig. 3.

Terminal bud obtuse, ovoid, always flanked; three pairs of scales covered with heavy scurfy pubescence, dark brown, outer pair slightly longer than inner and often truncate to form apical notch. Lateral buds small, rounded. Leaf scars oblong, obconic, at ten to thirty degree angle with twig, upper edge protruding slightly, surface of scar often ridged due to raised bundle scars. Twigs stout, sparsely tomentose, pubescence usually not persisting after the first year. Inner bark shiny brick-red.

4. **Fraxinus oregona** Nutt. Plate 87, Fig. 4.

Terminal bud obtuse, apiculate, about as broad as long, always flanked; four pairs of scales, outer pair as long as inner, scurfy-pubescent. Lateral buds rounded, scurfy-pubescent. Leaf scars semi-orbicular to crescent-shaped, at forty-five degree angle with twig, upper edge wavy, protruding slightly. Twigs stout, unevenly tomentose. Pubescence heaviest at the node. Bark of twig greyish green beneath pubescence. Inner bark brick-red to light buff.

5. **Fraxinus pennsylvanica** var. **lanceolata** Sarg. Plate 87, Fig. 5.

Terminal bud acute, always flanked; three pairs of scales, outer pair sometimes truncate, rufous-tomentose, brown to black. Lateral buds rounded or angular. Leaf scars semicircular, usually nearly parallel with twig, upper edge protruding. Twigs stout, ashy grey. Bark of twig below leaf scars sometimes brick-red. Inner bark shiny brick-red.

6. **Fraxinus americana** L. Plate 87, Figs. 6 & 7.

Terminal bud obtuse, ovoid, always flanked; three to four pairs of scales, scurfy-puberulous, brown to nearly black, broader than long, outer pair of scales shorter than inner pairs. Lateral buds rounded, often superposed on vigorous shoots. Leaf scars semiorbicular or crescent-shaped at forty-five degree angle with twig. Twigs stout, glabrous, often splotched with glaucous bloom. Inner bark shiny brick-red.

7. **Fraxinus texensis** Sarg. Plate 87, Fig. 8.

Terminal bud obtuse, ovoid, always flanked; three pairs of scales, minutely puberulous, light rusty-brown to dark brown, broader than long, outer pair shorter than inner and often truncated. Lateral buds flattened. Leaf scars semiorbicular to crescent-shaped, at forty-five degree angle with twig, upper edge protruding slightly. Twigs moderately stout, glabrous, often splotched with bloom. Inner bark shiny brick-red.

8. **Fraxinus syriaca** Boiss. Plate 88, Fig. 9.

Terminal bud acute, flanked or nearly so; scales whorled, those of outer whorl foliar and thickened on back, dark brown, slightly puberulous, hairy at tip. Lateral buds rounded. Leaf scars semiorbicular, whorled, small, dark colored, upper edge not protruding, at forty-five degree angle with twig, elevated. Twigs stout, glabrous, shiny green. Inner bark light buff.

9. **Fraxinus potamophila** Herd. Plate 88, Fig. 10.

Terminal bud acute, always flanked; outer scales with foliar tip, thickened on back, slightly puberulous, dark brown. Lateral buds small, rounded to angular. Leaf scars semicircular, small, dark colored, at forty-five degree angle with twig, elevated, upper edge not protruding. Twigs stout, dark grey-brown and glabrous. Bark often light tan around rim of leaf scars. Inner bark life buff.

10. **Fraxinus quadrangulata** Michx. Plate 88, Fig. 11.

Terminal bud acute, always flanked; three pairs of scales, outer pair longer than inner, keeled on back, tip of outer pair usually decidedly foliar, hoary-tomentose pubescence, light buff. Lateral buds rounded to somewhat flattened. Leaf scars semiorbicular to crescent-shaped, more or less flattened on lower edge, at forty-five degree angle with twig, upper edge protruding very slightly. Twigs stout, more or less four-angled between the node. Pubescence short, rufous, heaviest at the nodes. Inner bark light buff. Lenticels often grouped beneath the leaf scars.

11. **Fraxinus mandshurica** Rupr. Plate 88, Fig. 12.

Terminal bud acute, always flanked; three pairs of scales, outer pair usually foliar, second pair occasionally so, dark brown, minutely puberulous, lateral buds angular, divergent. Leaf scars crescent-shaped, at forty-five degree angle with twig, elevated, upper edge hairy, protruding. Twigs often slender, flattened at nodes causing twig to have somewhat quadrangular internodes, glabrous. Inner bark light buff.

12. **Fraxinus holotricha** Koehne. Plate 88, Fig. 13.

Terminal bud acute, always flanked, usually at 90 degree angle with twig; three pairs of scales, outer pair with foliar tips, first and second pairs decidedly thickened on back and wooly along the side, dark brown. Lateral buds angular. Leaf scars semicircular, at ten degree angle with twig, upper edge protruding and hairy. Twigs slender, villous-tomentose. Inner bark light buff.

13. **Fraxinus oxycarpa** Willd. Plate 88, Fig. 14.

Terminal bud acute, always flanked; usually two pairs of scales, the outer pair foliar and longer than inner pairs, thickened on back, dark brown, slightly puberulous. Lateral buds small, rounded to somewhat angular. Leaf scars semicircular, thirty degree angle with twig, slightly elevated, upper edge protruding. Twigs often slender, flattened at nodes, glabrous. Inner bark light buff.

14. **Fraxinus excelsior** L. Plate 88, Fig. 15

Terminal bud obtuse, ovoid, always flanked; three pairs of scales, the outer pair about as long as the inner and having a more or less foliar tip, slightly puberulous, nearly black. Lateral buds rounded, sometimes with scattered, silky pubescence on the outer side. Leaf scars semicircular to semiorbicular, elevated, upper edge noticeably protruding. Twigs, stout, glabrous. Inner bark light buff.

15. **Fraxinus nigra** Marsh. Plate 88, Fig. 16.

Terminal bud acute, always solitary; three pairs of scales, the outer pair more or less foliar at the tip, thickened on back, dark brown, puberulous. Lateral buds small. Leaf scars orbicular, concave when viewed from the side due to the protruding upper edge, from nearly parallel to ten degree angle with twig. Bundle scars conspicuous. Twigs stout, glabrous except for small dots of scurfy pubescence just below the terminal bud. Inner bark light buff.

ACKNOWLEDGMENTS

The author wishes to take this opportunity to express his gratitude and appreciation for the many suggestions and encouragements offered by Dr. Richard Fisher, director of the Harvard Forest, Petersham, Mass., and Dr. Edgar Anderson, of the Arnold Arboretum, under whose supervision this investigation was carried out. Thanks are also due to Dr. Charles C. Deam of Bluffton, Ind., Professor Frederick S. Page of Dartmouth College, and Mr. Paul A. Kohl of the Missouri Botanical Gardens for specimens gathered by them and used by the author in this study.

EXPLANATION OF THE PLATES.

Plates 87 and 88

Terminal and lateral buds of Fraxinus (× 3). Taken with a micro-tessar lens under approximately equal magnification and illumination.

Plate 87. Species of § Melioides: 1, *F. pennsylvanica*, 2, *F. biltmoreana*; 3, *F. profunda*; 4, *F. oregona*; 5, *F. pennsylvanica* var. *lanceolata*, 6, *F. americana* (whorled); 7, *F. americana*; 8, *F. texensis*.

Plate 88. Species of § Bumelioides: 9, *F. syriaca*; 10, *F. potamophila*, 11, *F. quadrangulata*, 12, *F. mandshurica*, 13, *F. holotricha*, 14, *F. oxycarpa*; 15, *F. excelsior*; 16, *F. nigra*.

Plate 89

Variation in Fraxinus twigs. Collections of the same species from various points.

Nos. 1 to 5, *F. americana*; 1, St. Louis, Missouri; 2, Indiana; 3, Granville, Mass.; 4, Norwich, Vt.; 5, Arnold Arboretum.

Nos. 6 to 8, *F. pennsylvanica* var. *lanceolata*; 6, Indiana; 7, Indiana; 8, Arnold Arboretum.

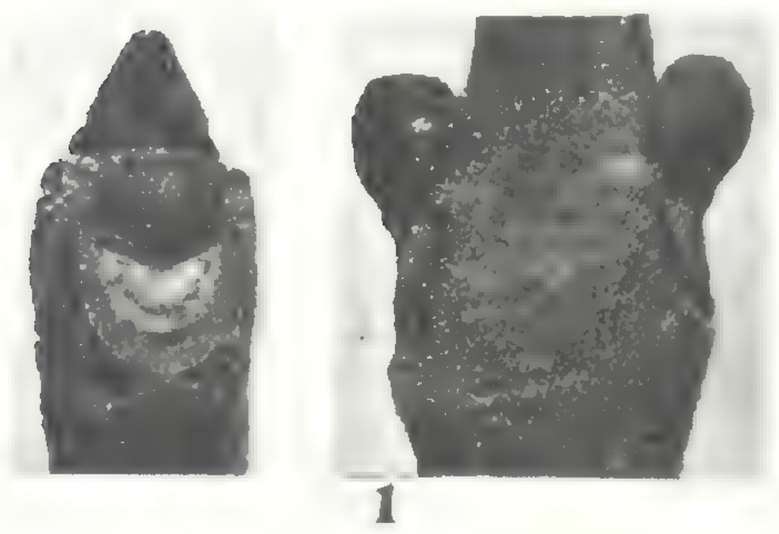
Nos. 9 & 10, *F. profunda*; 9, Arnold Arboretum; 10, Indiana.

Nos. 11 & 12, *F. quadrangulata*; 11, St. Louis, Missouri; 12, Indiana.

Nos. 13 & 14, *F. pennsylvanica*; 13, Dedham, Mass.; 14, Newton, Mass.

Nos. 15 & 16, *F. nigra*; 15, Petersham, Mass.; 16, Hanover, N. H.

ARNOLD ARBORETUM, HARVARD UNIVERSITY, AND
HARVARD FOREST, PETERSHAM, MASS.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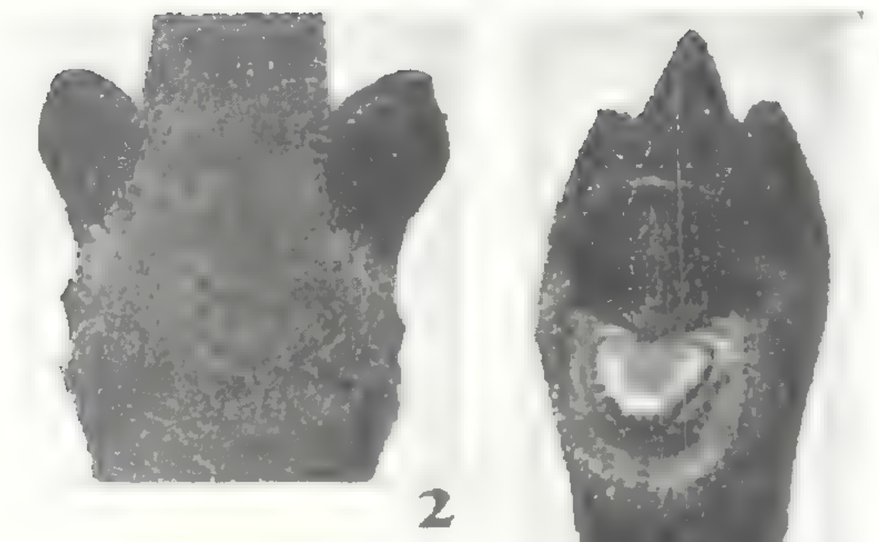
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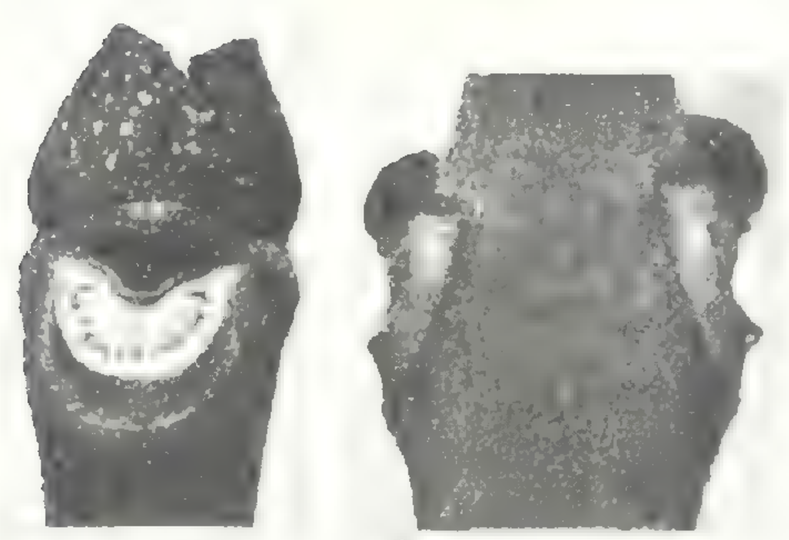
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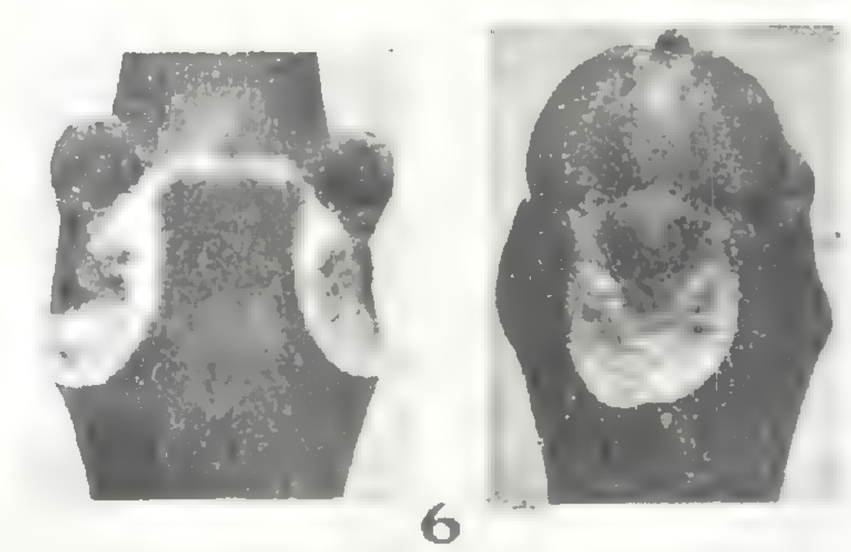
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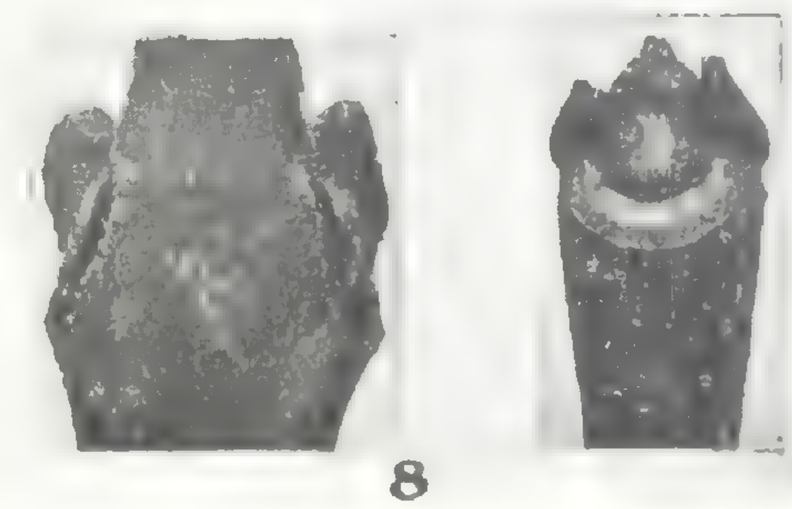
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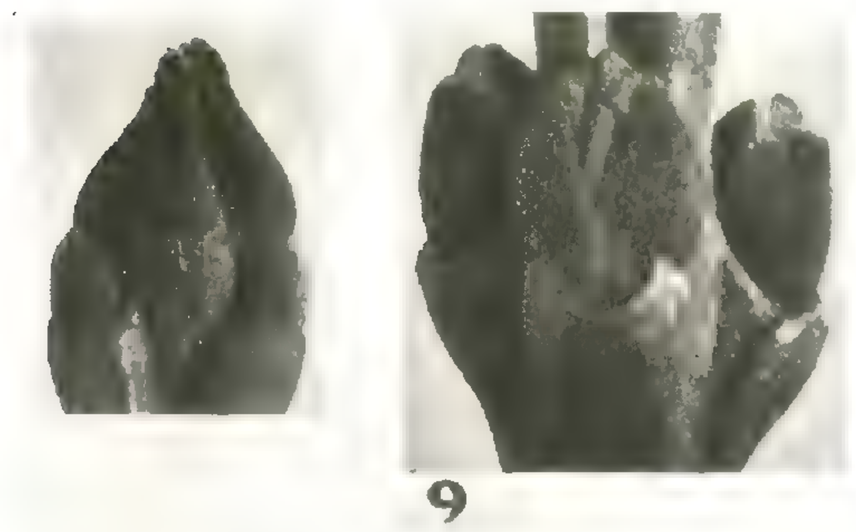

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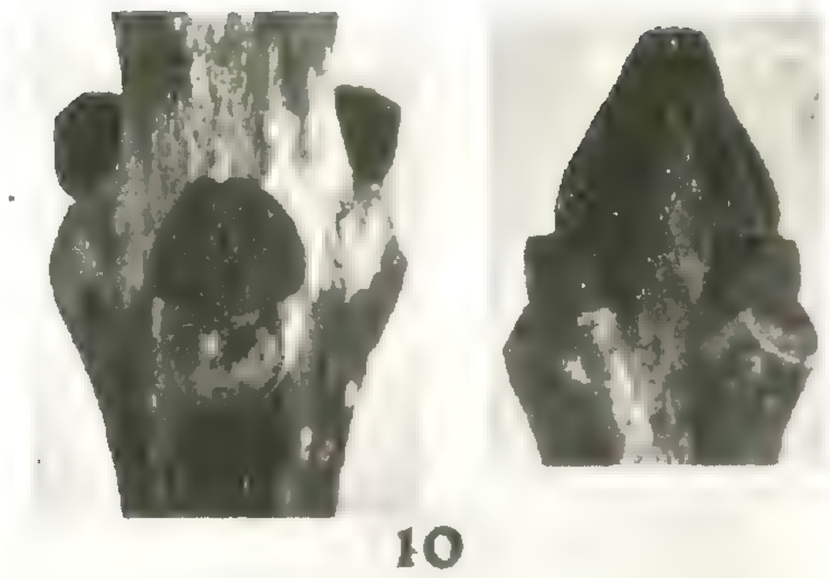

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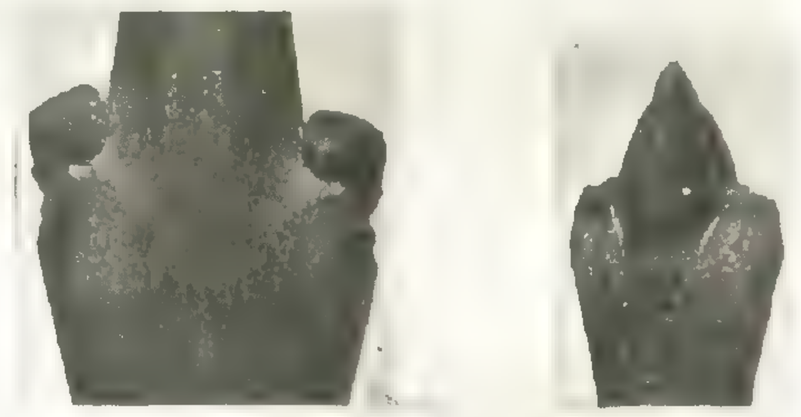

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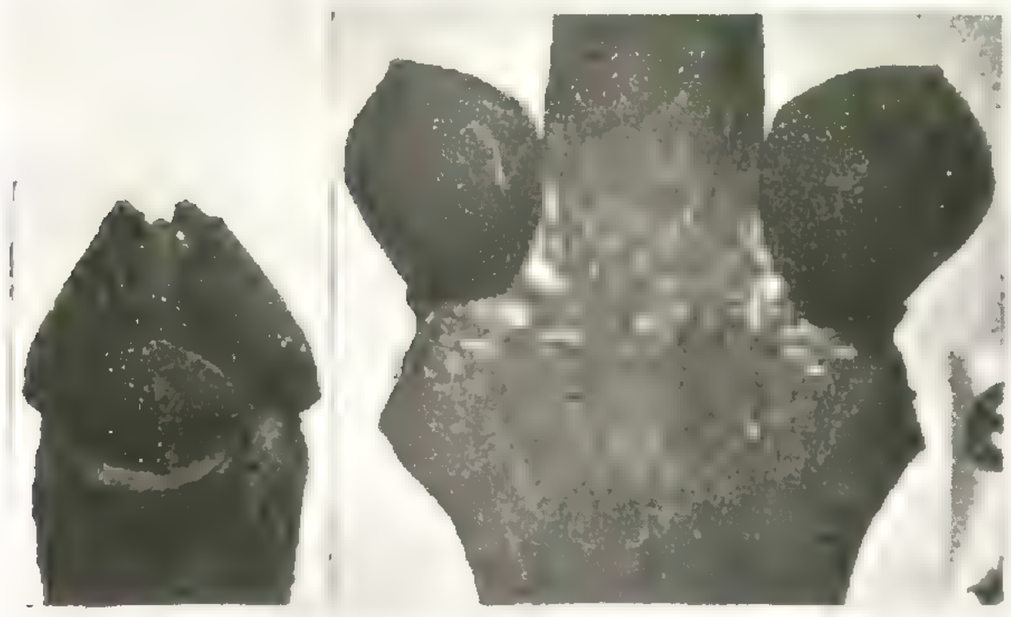

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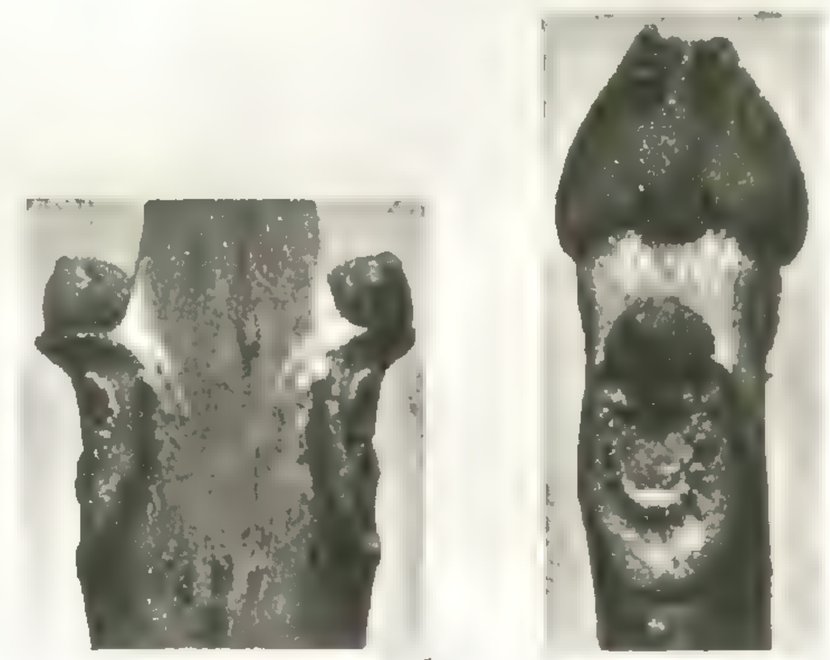

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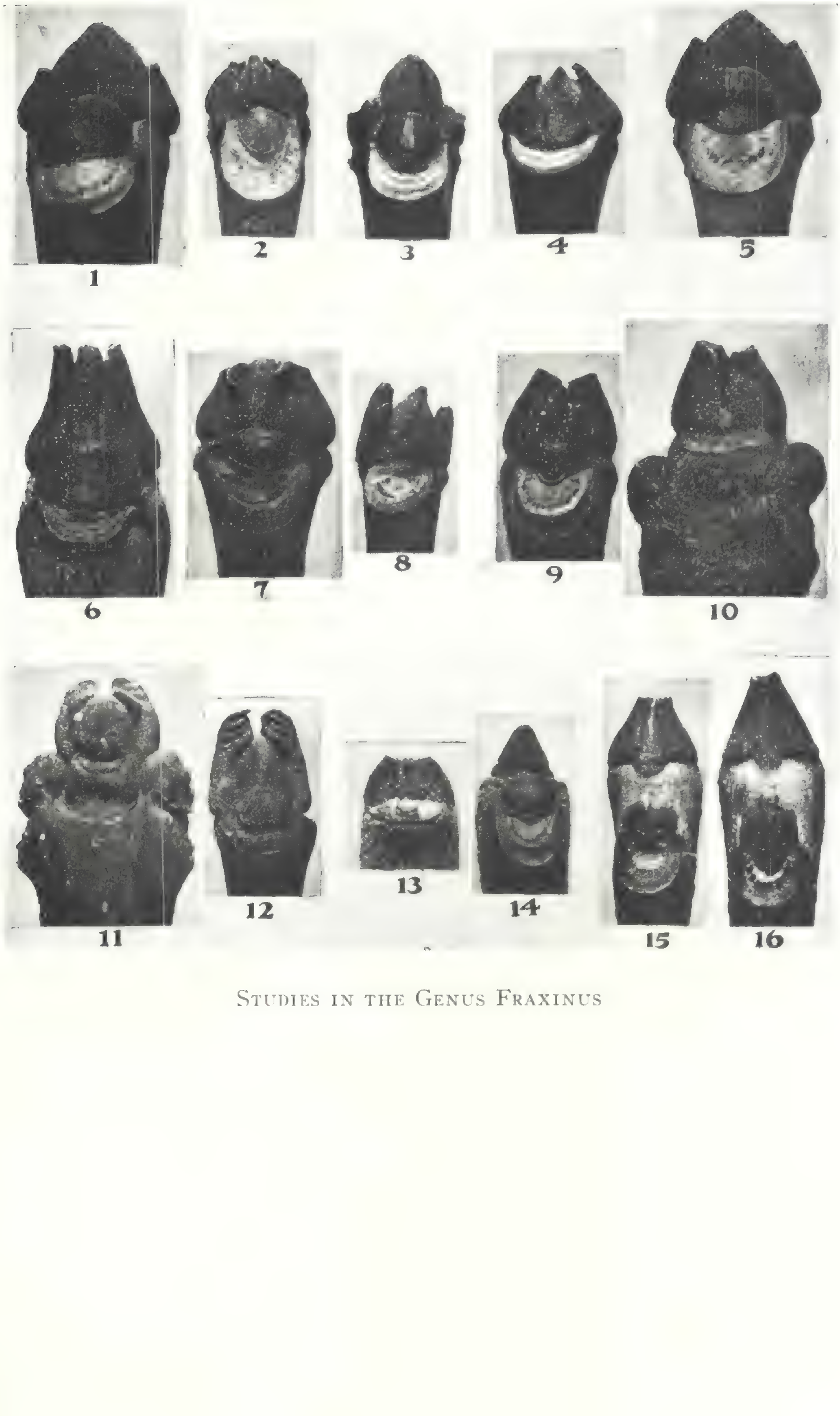

STUDIES IN THE GENUS FRAXINUS

NOTES ON SOME PLANTS OF OKLAHOMA

ERNEST J. PALMER

IN JULY, 1933, I spent about a week collecting in Oklahoma, entering the state near the northwest corner, approximately on the 101st meridian. Traveling in a south and east direction we crossed the North Canadian River at Beaver, and mainly followed the course of that stream to Woodward. From that point a side trip was made to Grand, in Ellis County, before turning south to the Wichita Mountains, east to the Arbuckle Mountains, and south and east to Hugo, where we crossed Red River into Texas.

In this very hasty dip into the flora of the state, some parts of the trip being in localities I had not visited before, a number of interesting plants were found, some of which have not, so far as I know, been previously reported from Oklahoma.

In the northwest part of the state we were in a typical plains country, with very few native woody plants. The weather was extremely dry, practically no rain having fallen for several months according to reports, and as a visible result trees planted about the primitive farm and ranch houses were dead or dying in many places, and few herbaceous plants were in evidence except along ravines and the borders of streams. Cottonwood trees, the black and sand-bar willow, and the willow-leaved groundsel (*Baccharis salicina*) are common along most small streams, and a few other species begin to appear along the rivers, especially where the country is sandy, as is the case in the vicinity of Beaver. Stopping along a little spring-fed tributary of the North Canadian a mile or two north of that town we were in the edge of the sand hills and dunes with a characteristic flora. The only arborescent species on the dry hills was the hackberry (*Celtis reticulata* var. *vestita*), and these trees were of small size. *Rhus trilobata* and the sand grape, *Vitis Longii,* formed large thickets, with occasional clumps of small plum bushes (*Prunus angustifolia*); *Berula erecta, Samolus parviflorus, Juncus Torreyi, Euphorbia petiolata* and *Asclepias incarnata* were growing along the immediate margins or banks of the little stream, and farther back in the sand dunes we collected *Stillingia sylvatica, Oreocarya suffruticosa, Palafoxia Hookeriana* and *Berlandiera texana.*

Near Laverne, in Harper County, a short stop was made to collect along the gravelly shallow bed of a creek, now entirely dry. *Eustoma*

Russellianum was growing here. This plant of the Gentian family, with its large deep purple flowers and glaucous foliage, is one of the handsomest wild flowers of the plains. Here also we found *Indigofera leptophylla, Cristatella Jamesii, Heliotropium convolvulaceum, Eriogonum annuum, Solidago glaberrima* and several other species which were managing to flower in spite of the drought.

North of Dunlap the dunes are extensively developed. The sage brush covers large areas, and thickets of *Prunus angustifolia* are numerous in slight depressions. Occasional clumps of *Yucca glauca* and of the tall grass, *Calamagrostis gigantea,* stood out conspicuously, and a tall crucifer, *Dithyrea Wislizenii* with its white flowers and curious seed pods, somewhat like a pair of spectacles or a figure eight in outline, was abundant in places.

At Woodward we visited the Northern Great Plains Experiment Station, of the U. S. Department of Agriculture, and were surprised to see the number of native and exotic trees and shrubs that are being grown here, testing their adaptability to the very trying conditions of this part of the country with its comparatively cold winters, hot summers and frequent long periods of drought, which in combination with the variety of soils and other factors makes a most complex problem for the pursuit of agriculture and horticulture even in the subordinate rôle that it plays and seems destined to play in a country more adapted to stock raising and grazing.

We were particularly interested, however, in the native flora, and after having been shown over the station, in the absence of the Director, Mr. E. F. Chilcott, we were guided on a collecting trip by Mr. L. F. Locke and two other members of the staff.

The flora in the vicinity of Woodward is distinctly more varied and abundant than that through which we had been passing farther west in the "Panhandle" counties, and it begins to take on more of the aspect of the southern plains, with but slight resemblance to that of the Mississippi valley and the Middle States. Looking over the landscape from a point of vantage the most striking botanical feature is the shrubby oaks, growing in thickets or "mottes" of varying size from two or three meters to twenty meters or more in diameter. The formation is dense; the largest shrubs near the center are sometimes two or three meters high, decreasing gradually in size towards the margins. There are two varieties of the post oak, *Quercus stellata* var. *rufescens* Sarg. and *Q. stellata* var. *parviloba* Sarg., and with them a more slender species of quite different habit, *Quercus Havardi* Rydb. This species usually grows with single or only a few stems, a meter or a

meter and a half in height, which are often weighed down to the ground with the large crop of heavy acorns. The post oaks apparently propagate both by stolons and seedlings, but probably more commonly by the latter method, as they produce large crops of acorns in most seasons and these germinate readily in the sandy soil in seasons where there is a normal amount of rainfall. Thickets of both *Prunus angustifolia* and *P. gracilis* are frequent as well as *Yucca glauca* which is conspicuous on the dryer slopes and summits of the sand hills. Thickets begin to appear along the smaller streams, in which *Celtis reticulata* var. *vestita*, *Rhus glabra, Ptelea trifoliata, Celastrus scandens, Ampelopsis cordata, Sapindus Drummondii* and *Bumelia lanuginosa* were noted.

Going southward into Ellis County we passed through miles of this type of flora with the mottes of scrub oak scattered over the sand hills stretching as far as could be seen. At the old town of Grand, once an important trading center for this part of the country, but now reduced to a single general store and two or three houses, we came to the main or southern branch of the Canadian River. The country bordering the river at this point is hilly and deeply eroded with ravines and gullies leading down to the alluvial valley. Some of these ravines or small cañons furnish protection to trees and other plants that cannot grow on the plains and that are found nowhere else in this part of the country. One of the most interesting trees of the cañons is *Juglans major* (Torr.) Heller[1], the largest specimens of which were 7 or 8 meters high. Some of the trees were in fruit and old fruit was found under others. There is much variation in the size and shape of the nuts of this species here as in other parts of its range, and the reports of *Juglans rupestris* Engelm. from Oklahoma are probably based upon small-fruited forms of this. At least, I have not seen the latter species in Oklahoma and its range probably does not extend as far north. These trees had been discovered and kept under observation by the botanists of the Experiment Station and seedlings of several of them are in cultivation there. Amongst other woody plants growing in the protection of the cañons were *Juniperus virginiana, Celtis laevigata* var. *texana, Morus rubra* and *Parthenocissus vitacea.* On dry gypseous banks a large-flowered evening-primrose, *Megapterium oklahomense* was in bloom, and a little farther up on open ground was found a shrubby cat's-claw, *Mimosa borealis.* On the hills the soil is gravelly and much eroded, with small masses of sandstone and chert and occa-

[1]Since I have returned to the Arboretum Mr. Lock has sent me specimens of *Juglans major* collected along the North Canadian River, northeast of Woodward, which extends the range of the species considerably farther north than it had previously been known.

sional fragments of silicified wood. *Ceanothus ovatus* var. *pubescens*, *Scutellaria resinosa* and *Houstonia angustifolia* are found along dry banks and ledges, and several sorts of cacti of the genera *Opuntia*, *Neomamillaria* and *Echinocereus* grow on the dry level areas. In the broader open spaces and along the foot of the hills, mesquite trees (*Prosopis juliflora*) are growing and *Ptelea polyadenia* was also collected here.

On leaving Woodward the next day we stopped for a few minutes just south of the little town of Sharon at the crossing of North Persimmon Creek. Here a few more eastern plants begin to put in an appearance. Amongst those seen along the creek were *Quercus macrocarpa*, *Q. Muhlenbergii*, *Morus rubra*, *Ribes odoratum*, *Rubus flagellaris*, *Cornus asperifolia* and *Cocculus carolinus*.

Proceeding south we arrived sometime in the afternoon at Hobart on the edge of the Wichita Mountains. This group consists of a series of knobs and ridges of granite and other igneous rocks, which, due to their greater resistance have been preserved as the softer sedimentary strata into which they were originally intruded, have been removed by erosion. Some of the domes stand out impressively on the sky-line, but they are seldom more than a few hundred feet above the surrounding plain.

Our first stop was made near the village of Lone Wolf, where we climbed some of the low foot-hills. *Juglans major* is rather frequent here growing in the protection of ledges and clefts, and the shrubby honeysuckle of the Southwest, *Lonicera albiflora* was also collected. Two southwestern ferns, *Cheilanthes Eatoni* and *Notholaena Hookeri* were growing in rubble and clefts of the granite, but most of the fronds were too much withered to be collected.

As there were no camping facilities here and it was getting late, we turned back east to Coopertown, just beyond which we entered the Wichita National Forest and stopped for the night at a camping place along a little mountain stream, now quite dry. The following morning Mr. Edward King, my traveling companion, and I set out to explore the surrounding region.

The forest is in most places very sparse, most of the woody species being confined to the vicinity of small streams and ravines or to the bases of the more precipitous hills. A few small trees and shrubs are found higher up on the hills or on their summits wherever there is a little irregularity of surface to afford some protection. There are wide open spaces between the hills with a grassy and herbaceous flora and sometimes with a few mesquite trees. Even along the mountain streams

and in the little valleys where the trees reach their largest size, there is little that can be called real forest. Post oak, black oak, mulberry, and hackberry are amongst the commonest tree, with cottonwood (*Populus balsamifera*), Ward's willow (*Salix longipes* var. *Wardii*), walnut (*Juglans major*), cat-briar (*Smilax Bona-nox*) and buttonbush growing along the immediate margins of the creeks. The big-tree plum (*Prunus mexicana*) and the false grape (*Ampelopsis cordata*) were also collected here. The red cedar (*Juniperus virginiana*) and black jack oak (*Quercus marilandica*) are sometimes found on the higher slopes or tops of the mountains, and the lead plant (*Amorpha canescens*) on dry rocky slopes. *Acacia angustissima* and a curious woody vine with fleshy leaves (*Cissus incisa*) were growing in clefts of the rock. A species of wafer ash, which appears to be *Ptelea aboriginum* Greene, was collected on a rocky open slope, and in a little cove a little higher up I found *Rubus oklahomus,* a species of blackberry recently described by Dr. Bailey, and near by was a large sized tree of *Crataegus Stevensiana* Sarg., which was the only species of this large group seen in the forest.

On a north slope, below a small granite bluff, a small thicket of the western choke cherry (*Prunus virginiana* var. *demissa*) was growing and in clefts of the bluff we collected the marginal shield fern (*Thelypteris marginalis*) and *Arenaria stricta* var. *texana.* Before returning to the camp we crossed an open valley to another granite ridge with a rather heavy growth of woods along the base. In the rubble and large detached masses of rock here we found the little Rocky Mountain maple (*Acer grandidentatum*). As it grows here, it is a stout shrub not more than two or two and a half meters in height, with branches scarcely extended above the height of the rocky walls in the protection of which it was growing. This is the most eastern known limit for this western species and its presence here is particularly interesting as indicating a former invasion of Rocky Mountain plants into the region. Another shrubby plant that attracted our attention from its showy appearance was a form of *Cephalanthus occidentalis* growing in springy ground along a little creek, and covered with fruit of a bright red color. This might very well be used as an ornamental plant if the color of the fruit could be retained in cultivation.

Herbaceous plants were not much in evidence at this dry season. Amongst the most conspicuous were *Eriogonum longifolium, Grindelia nuda, Gaillardia pulchella* and *Thelesperma ambiguum,* which were still flowering. I also collected *Portulaca lanceolata* in decomposed granite near Lone Wolf, *Aristida Wrightii,* which is one of the commonest

grasses, *Houstonia angustifolia, Scutellaria resinosa* and *Commelina erecta* in rocky open ground, and *Cyperus Schweinitzii* and *Sabbatia campestris* in moist ground along a little brook.

After having lunch we loaded the car and set out eastward towards Paradise Springs where we planned to stop for the night. Several stops were made to take photographs of the hills and of some of the plants, and to collect plants along a branch of Cache Creek. This was a rather larger stream than those we had been on before and additional species began to appear. The chinquapin oak (*Quercus Muhlenbergii*) and the red and green ash (*Fraxinus pennsylvanica* and *F. pennsylvanica* var. *lanceolata*) were growing along the creek bank. We crossed this stream or another branch of it again near the Forest Headquarters, and here we added the pecan (*Carya pecan*), Schneck's oak (*Quercus Shumardii* var. *Schneckii*) and the little sand grape (*Vitis rupestris*) to our list. The grape vine was growing in the shingle and gravel of the creek bed and trailing over the larger rocks, which is a characteristic habitat for this species. Only one tree of Schneck's oak was seen on the creek bank here, but it becomes commoner a little farther south and west, where I have collected it near the village of Cache.

The following day, without having made other stops, we arrived at the Arbuckle Mountains, stopping first to have lunch at Turner Falls State Park, which has been made a popular resort. Here we were in a region of striking contrast in many respects to the Wichita Mountains. If the Wichita Mountains are such only by courtesy, it might be thought to put a strong tax upon the proprieties or at least upon scientific accuracy to designate the Arbuckle region as a mountainous one. The low rounded hills are underlaid largely by a hard Paleozoic limestone, through which has been thrust a mass of porphyritic intrusive rocks that now come to the surface over a small area. The limestone is exposed on many of the hill tops and slopes and as bluffs at some places along the Washita River which traverses the region. The soil is therefore decidedly alkaline over much of the area, although it is sandy and more acid in parts of the river valley as well as where the igneous rocks are exposed. The general aspect of the country with the outcrops of hard pure limestone eroded by occasional torrential rains that interrupt the usually dry climate, give it a strong resemblance to parts of the Edwards plateau in central Texas, an impression which a study of the flora strongly confirms. The following list of plants, although necessarily a very incomplete one, resulting from collecting for only parts of two days, clearly shows this relationship, and it is scarcely

an exaggeration to say that the Arbuckle Mountains, so far as the flora is concerned, constitutes a northern extension and the farthest outpost of that interesting flora.

Cheilanthes Feei Moore
Cheilanthes tomentosa Link
Pellaea atropurpurea (L.) Link
Juniperus mexicana Spreng.
Uniola latifolia Michx.
Carya Buckleyi Durand
Carya cordiformis (Wangh.) K. Koch
Juglans major (Torr.) Heller
Quercus Muhlenbergii Engelm.
Quercus prinoides Willd.
Quercus texana Buckley
Quercus Shumardii var. Schneckii (Britt.) Sarg.
Ulmus alata Michx.
Celtis laevigata Willd.
Morus microphylla Buckley
Clematis Simsii Sweet
Ribes odoratum Wendl.
Rosa carolina L.
Rosa foliolosa Nutt.
Rubus trivialis Michx.
Crataegus bellica Sarg.
Crataegus limaria Sarg.
Crataegus viridis L.
Sophora affinis T. & G.
Cercis reniformis Engelm.
Psoralea Reverchoni Wats.
Amorpha canescens Pursh
Phyllanthus polygonoides Spreng.
Acalypha gracillima var. monococca Engelm.
Rhus copallina L.
Rhus copallina var. lanceolata Gray
Aesculus arguta Buckley
Ceanothus ovatus var. mollis T. & G.
Rhamnus caroliniana var. mollis Fern.
Ptelea nitens? Greene
Abutilon incanum Don
Sapindus Drummondii H. & A.
Vitis cordifolia Lam.
Vitis rupestris Scheele
Ampelopsis arborea (L.) Koehne
Hypericum cistifolium Lam.
Ascyron hypericoides L.
Opuntia leptocaulis DC.
Convolvulus incanus Vahl
Evolvulus argenteus Pursh
Heliotropium tenellum (Nutt.) Torr.
Verbena bipinnatifida Nutt.
Fraxinus texensis (Gray) Sarg.
Forestiera pubescens Nutt.
Satureja arkansana (Nutt.) Briq.
Lonicera albiflora T. & G.
Viburnum rufidulum Raf.
Grindelia lanceolata Nutt.
Helianthus hirsutus Raf.

Particularly significant is the occurrence here of such typically Texan species as *Juniperus mexicana, Carya Buckleyi, Quercus texana, Morus microphylla, Cercis reniformis, Psoralea Reverchoni, Rhus copallina* var. *lanceolata, Abutilon incanum, Opuntia leptocaulis* and *Fraxinus texensis*. Many of the other plants are also characteristic species of the Edwards plateau flora although of somewhat wider range. Several of the plants on the list, which have a generally more northern

and eastern range, as for example *Carya cordiformis, Rosa carolina, Rhus copallina, Vitis cordifolia* and *Ascyron hypericoides,* were not collected or noted on or near the limestone outcrops but along the river or in areas having a different type of soil.

Specimens of all of the woody plants mentioned in this paper are deposited in the herbarium of the Arnold Arboretum, and the herbaceous species may be found in the Gray Herbarium. Duplicates of most of them have been distributed to other institutions.

HERBARIUM, ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

CHROMOSOME CONSTITUTION IN CERTAIN MONOCOTYLEDONS

THOMAS W. WHITAKER

With nine text figures

MCKELVEY AND SAX (1933) have called attention to the existence of taxonomic and cytological similarities between certain genera in the Liliaceae and Amaryllidaceae. The similarity is rather striking with regard to chromosome constitution. *Yucca, Hesperoyucca, Cleistoyucca, Hesperaloë,* and *Samuela,* in the Liliaceae, all have 5 long and 25 short chromosomes. *Agave* in the Amaryllidaceae has exactly the same chromosome constitution. These observations when considered in conjunction with taxonomic resemblances, seem to indicate that the genera mentioned above are more closely related than is shown by their separation into distinct families. With the object of discovering whether this pronounced heteromorphism (5 long and 25 short chromosomes) is of general occurrence throughout the monocotyledons, a number of species have been examined.

After a casual survey, the species enumerated below were selected for further study as being the most interesting from the point of view of the problem under investigation.

1. *Polyanthes tuberosa* L. ..... Amaryllidaceae
2. *Fourcroya gigantea* Vent. ..... Amaryllidaceae
3. *Fourcroya Selloa* C. Koch ..... Amaryllidaceae
4. *Fourcroya Bedinghausii* C. Koch ..... Amaryllidaceae
5. *Doryanthes Palmeri* W. Hill ..... Amaryllidaceae
6. *Hosta coerulea* (Andrews) Tratt. ..... Liliaceae
7. *Dasylirion longissimum* Lem. ..... Liliaceae
8. *Nolina recurvata* Hemsl. ..... Liliaceae
9. *Butomus umbellatus* L. ..... Butomaceae

The chromosome counts were secured from root-tip material, prepared by the smear-maceration method and stained with aceto-carmine (Whitaker, 1934). In the case of *Hosta* and *Polyanthes,* the root-tip material has been augmented by counts from pollen mother cells.

Chromosome counts during meiosis indicate that *Polyanthes tuberosa* has 30 chromosomes. The chromosome constitution in this species is identical with that of the *Yucca-Agave* group. The shape and size of

the 5 long chromosomes are comparable with figures from similar stages in either *Yucca* or *Agave* (Fig. 1).

In *Fourcroya gigantea* the somatic chromosome number appears to be 60. The chromosome complement of this species consists of 10 distinctly long chromosomes and 50 short ones (Fig. 2). Counts from root-tip cells of *F. Bedinghausii* and *F. Selloa* show that these two species also have 60 somatic chromosomes. The morphology of the chromosome complement in the case of the latter two species is the same as that of *F. gigantea*.

1

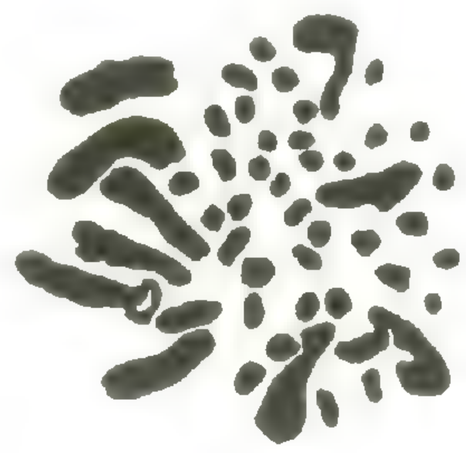

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FIGURE 1. POLYANTHES TUBEROSA. 30 chromosomes at metaphase. About × 2100. — FIGURE 2. FOURCROYA GIGANTEA. 60 chromosomes at metaphase. About × 2100.

Doryanthes is the sole representative of the sub-family Agavoideae not indigenous to the desert areas of North America. The three species of this genus are all natives of Australia. *Doryanthes Palmeri,* the species from which the material was secured, has 36 somatic chromosomes (Fig. 3). On morphological grounds the chromosome complement of this species is not at all comparable with that of the North American species of the Agavoideae (compare Fig. 2 with Fig. 3). The 5 long pairs of chromosomes which are one of the conspicuous features of the chromosome set-up in *Agave, Yucca, Fourcroya,* etc. are absent in *Doryanthes Palmeri.* Long and short chromosomes are present, but there is not the same degree of difference which exists between the long and short chromosomes of the *Yucca-Agave* group. Thus there are two categories of evidence, cytological and distributional, which are opposed to the placing of *Doryanthes* in the sub-family Agavoideae.

Hosta coerulea has 30 meiotic chromosomes (Fig. 4). The chromosome constitution in this species appears to be similar to that of the *Yucca-Agave* group. There exists the possibility that one of the long chromosomes may not equal the size of the four remaining long ones. If this difference exists, it is slight, and with this exception, it is clearly apparent that the chromosome morphology of this species is

fundamentally the same as that found in *Yucca, Agave, Fourcroya,* etc. Miyake (1906) has figured the chromosomes of *Hosta Sieboldiana*. His figures show the 5 long chromosomes quite plainly, but the total number seems to be somewhat less than the 30 pairs found in *H. coerulea*. It is interesting to note that the 5 long chromosomes were also found in *H. Sieboldiana*.

3

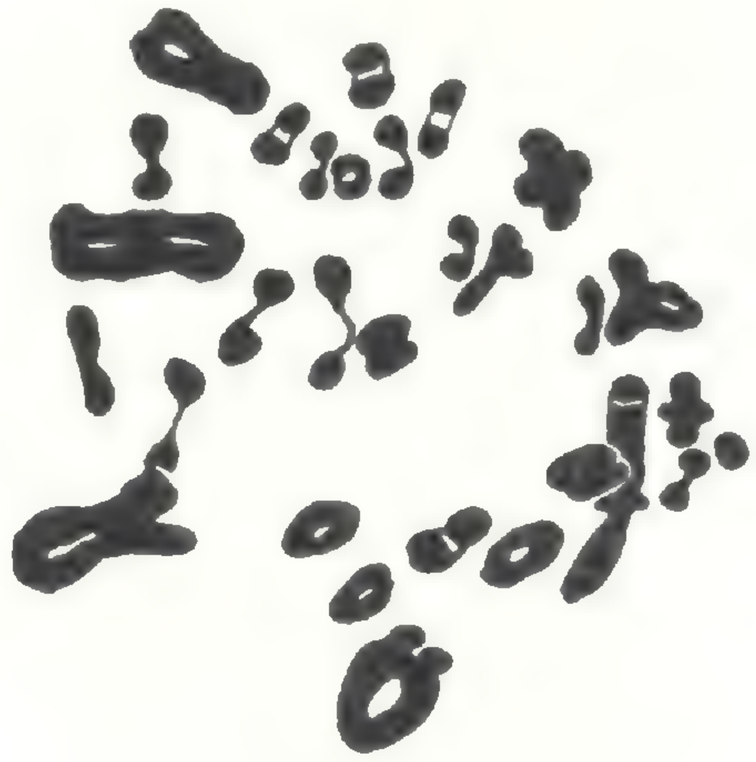

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FIGURE 3. DORYANTHES PALMERI. 36 chromosomes at metaphase. About × 2100. — FIGURE 4. HOSTA COERULEA. 30 chromosomes at diakinesis. About × 2500.

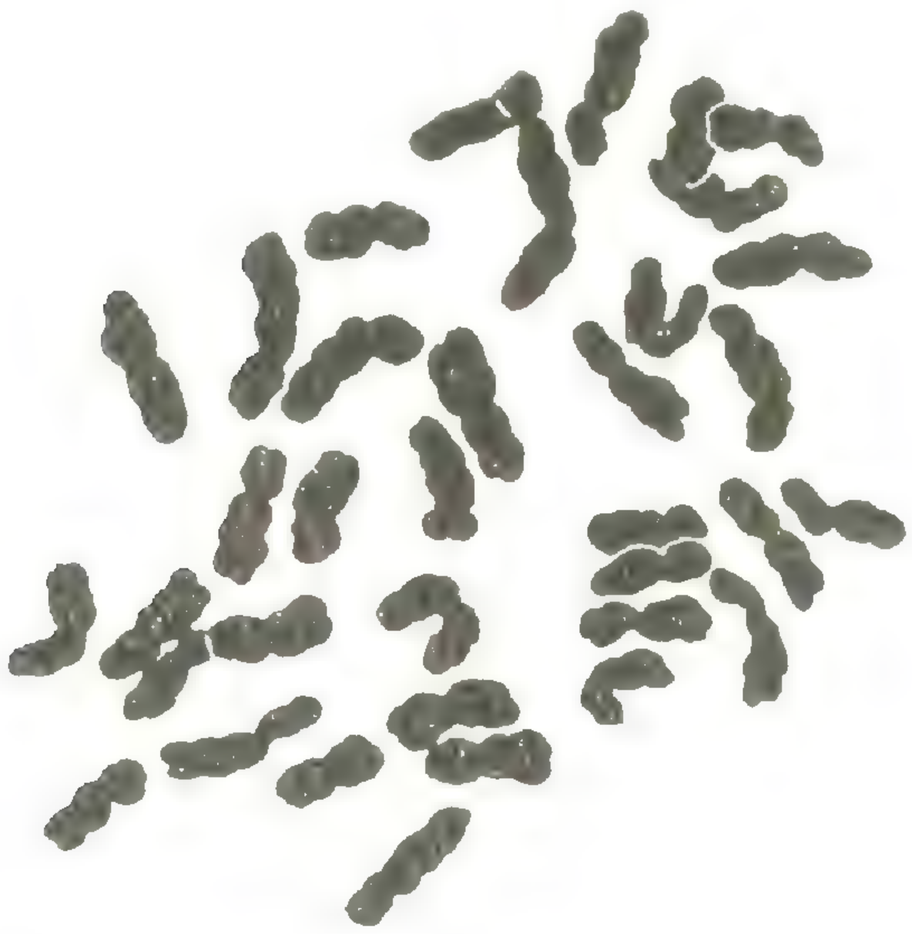
Dasylirion, Nolina, and *Dracaena* have been examined with the purpose of discovering a possible connecting link between these genera and the *Yucca-Agave* group. According to Johnston (quoted in McKelvey and Sax, 1933), if an affinity between the Yuccas in the Liliaceae and the Agaves in the Amaryllidaceae is to be established, it is most likely to be traced through the genera mentioned above. *Dasylirion* and *Nolina,* have distributions which closely parallel that of the *Yucca-Agave* group. Cytologically *Nolina* has nothing to contribute to the problem. *Nolina recurvata* has 36 pairs of chromosomes (Fig. 5) which are of approximately equal length. The attachment constrictions are median or sub-median in most cases.

Dasylirion longissimum seems to have 38 chromosomes, three pairs of which are very nearly twice the length of the shorter chromosomes (Fig. 6). The size difference between the long and short chromosomes of this species are not nearly as striking as the differences existing in the chromosome complement of the members of the *Yucca-Agave* group.

Dracaena arborea has about 38 chromosomes, according to McKelvey and Sax (1933). The writer has examined another species of *Dracaena* (*D. fragrans* Ker-Gawl.). This species also seems to have about 38

chromosomes, all of which are very small and very nearly of equal length.

So far as the cytological observations already completed are concerned, *Nolina*, *Dracaena*, and *Dasylirion* obviously do not point the way to further progress with the problem. *Nolina* and *Dracaena*, by reason of the morphology of their chromosome complements, can be eliminated from further consideration. *Dasylirion* has possibilities, but on the basis of its chromosome complement alone, there are not sufficient grounds for thinking of it as closely allied to the *Yucca-Agave* group.



5

6

FIGURE 5. NOLINA RECURVATA. 36 chromosomes at metaphase. About × 2500. — FIGURE 6. DASYLIRION LONGISSIMUM. 38 chromosomes at metaphase. About × 2500.

Butomus umbellatus[1] has 26 somatic chromosomes (Fig. 7). Early studies on embryo sac development, where chromosome number was reported incidentally, have led to some confusion. Holmgren (1913) has stated that the reduced number in this species is 11-12. Liehr (1916) has placed the reduced number at 8. Terby (1922), who has evidently made a very careful study of the somatic chromosomes of this species, finds 40 chromosomes. Apparently the plant or plants from which she secured her material must have been triploid in origin. In Fig. 7, where the 26 somatic chromosomes of *Butomus umbellatus* are shown at metaphase, four pairs are noticeably longer than the remainder. It is this situation which suggests that Terby's material may have been of

[1]The writer is indebted to Professor C. L. Huskins, McGill University, Montreal, Canada, for the material of *Butomus umbellatus*.

triploid nature because if another genom of 13 chromosomes were added to the diploid complement of Fig. 7, there would be twelve long chromosomes, and that is exactly what happens, as the reproduction of Terby's figure shows (Fig. 8).

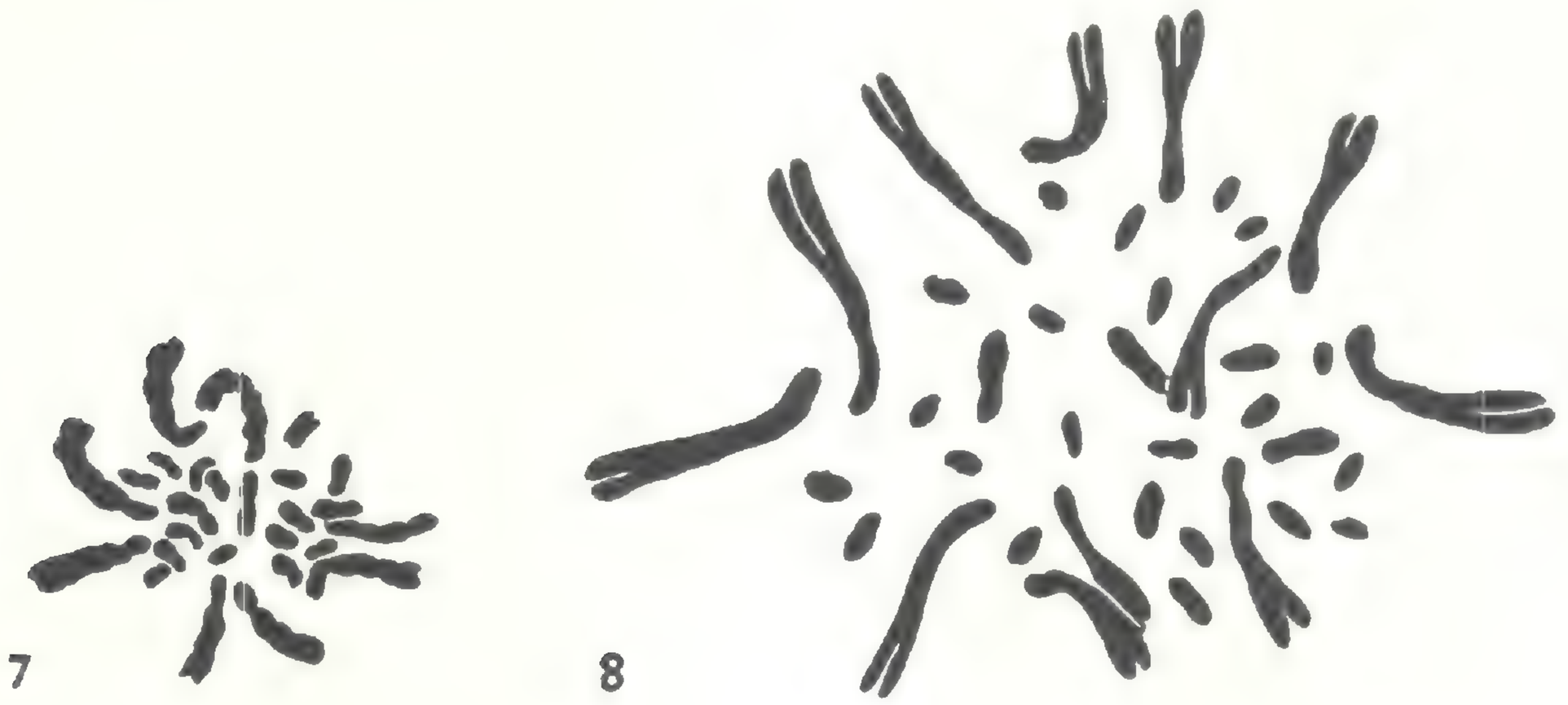


FIGURE 7. BUTOMUS UMBELLATUS. 26 chromosomes at metaphase. About × 2500. — FIGURE 8. BUTOMUS UMBELLATUS (probable triploid, after Terby).

The purpose of studying the chromosome complement of this species was to indicate that the size differences among the chromosomes are of the same general order as those found in *Yucca, Fourcroya, Agave,* etc. That this is actually the case is fully substantiated by a comparison of the chromosomes of *B. umbellatus* (Fig. 7) with those of members of the *Yucca-Agave* group, *Fourcroya* for instance (Fig. 2).

DISCUSSION

Heitz (1926) mentioned the correlation existing between taxonomy and chromosome constitution in the Agavoideae. His observations on *Fourcroya,* and those of Müller (1912) on *Beschorneria* and *Agave,* led to this conclusion. He states that not only do these genera belong to the same sub-family (Agavoideae), but they are also characterized by the same sort of chromosome constitution.

McKelvey and Sax (1933), as stated previously, have pointed out the similarities with respect to chromosome constitution between the Yuccae and the Agavoideae. The chromosome set-up of representative species of these two groups is strikingly similar, and in all visible respects, identical. These investigators have stated that it is unlikely that this is due to chance but must mean that these two groups are more closely akin to each other than is indicated by the prevailing system of classification which separates them into different families.

It is clear, from this brief review of previous work, that the point to be emphasized is that a chromosome set consisting of 10 long and 50 short chromosomes is sufficiently uncommon in the plant kingdom to lead one to suspect that species having this unique chromosome constitution are of common ancestry and closely related.

The present observations on *Polyanthes* and *Fourcroya* added to those of previous investigators, give a fairly complete story in regard to chromosome constitution in the Agavoideae. Pax and Hoffmann (1930) have listed seven genera belonging to this sub-family. Disregarding *Doryanthes,* which does not seem to fit into this group, four of the remaining genera have been examined, and all have exactly the same chromosome set-up. There are some possible exceptions. Heitz (1926) has reported *Fourcroya Lindenii* as having 10-12 long and 30-39 short chromosomes, and *F. altissima* with 10 long and 40 short chromosomes. It is likely that this may be an error, for the reason that the three other species of *Fourcroya* examined all have the usual complement of 10 long and 50 short chromosomes. These observations very definitely indicate a close cytological relationship between the members of this sub-family. It is reasonable to suppose that the members of the Agavoideae are taxonomically closely allied to the Yuccae. Johnston (quoted in McKelvey and Sax, 1933) has listed a number of similarities between these two groups.

To state the essential facts in a more concise form, we have five genera in the Liliaceae (*Hesperaloë, Hesperoyucca, Cleistoyucca, Yucca, Samuela*) and four genera in the Amaryllidaceae (**Fourcroya, Agave, Beschorneria, Polyanthes*), which, on distributional, taxonomic, and cytological grounds, are closely akin to each other. These facts should be given serious consideration in any taxonomic revision of these two families where an attempt is made to arrange the genera in a phylogenetic series.

In regard to *Hosta,* the situation is difficult to interpret. There can be little doubt that it is similar in chromosome constitution to the *Yucca-Agave* group. A careful study of a number of slides has not revealed a single consistent difference by which one would be able to distinguish the chromosome complement of the two species under discussion. *Hosta,* as now constituted, is placed in the sub-family Asphodeloideae, rather widely separated from *Yucca,* which has been placed in the Dracaenoideae (Krause, 1930). Superficially, the resemblance between *Hosta* and members of the *Yucca-Agave* group are

**Prochnyanthes* and *Pseudobravoa* are genera which fit into this group on distributional and taxonomic grounds. Species of these genera were not available for cytological studies and consequently had to be omitted.

slight enough to be almost negligible. If we retain the original supposition that the possession of an identical chromosome complement is an indication of a comparatively close relationship, it must mean that it is possible to obtain a far-reaching differentiation of specific characters without a drastic change in the morphology of the chromosome complement. It is probable that chromosome constitution may behave in a manner comparable to many morphological characters, that is to say, a certain character may flow along with the main body of evidence and then suddenly diverge to a point where it is no longer of significance. Therefore, chromosome constitution as a criterion of phylogenetic relationship should only be judged in so far as it fits in with other lines of evidence.

There is some cytological evidence suggesting that the peculiar heteromorphic chromosome set-up found in the *Yucca-Agave* group may indicate a fundamental relationship which can be traced through a number of families in the monocotyledons.

The evidence for the existence of this relationship is derived from both taxonomy and cytology, and seem to point to the following conclusions:

1. There is a group of families in the Helobiae, which represent primitive generalized types.

2. It appears as if the specialized chromosome set-up of the *Yucca-Agave* group may have had its origin among the families of this order.

In the classification of Wettstein (1924), the Helobiae are considered the most primitive monocotyledenous group. In this order occur among others, such presumably primitive families at Butomaceae, Najadaceae, Hydrocharitaceae, Triuridaceae, etc. If the chromosome complement of species representing the four families mentioned above is analyzed, some rather striking similarities are apparent. There are either four or five pairs of long chromosomes associated with a varying number of short ones, no single one of which is equal to one half the length of the longer chromosomes. The attachment constriction is either median or sub-terminal in the long chromosomes and usually terminal in the short chromosomes.

In Fig. 9, the five longest chromosomes from representative species of the four families listed above have been drawn diagrammatically. The measurements have been made from metaphase plates during mitosis. The drawings have been reduced to approximately the same scale. These diagrams seem to verify the assertion that there is some measure of similarity between the five longer elements in the chromosome complement of some of the species of these four families (Butomaceae, Hydrocharitaceae, Najadaceae, Triuridaceae).

The point I wish to make, in presenting this evidence, is that the five longer elements in the chromosome complement of these four species, show some resemblance to each other; and, furthermore, they are of the same general nature as that of the five longer elements in the chromosome complement of members of the *Yucca-Agave* group. This may well be a superficial resemblance of no significance whatever, but the taxonomic and cytological evidence combine to give it a certain weight worthy of more extended investigation.

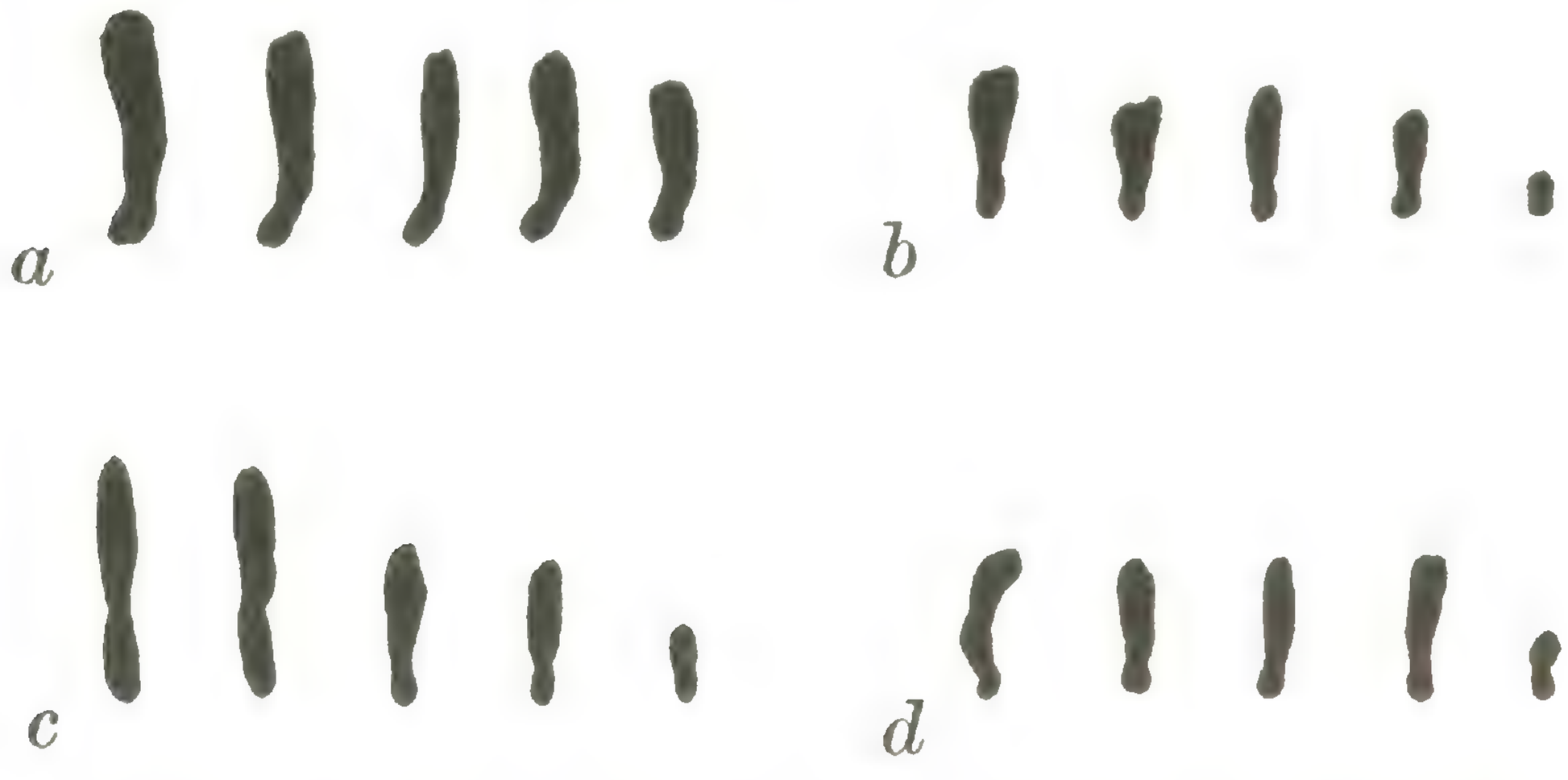


FIGURE 9. a. NAJAS MARINA L. (after Winge). — b. VALLISNERIA SPIRALIS L. (after Winge). — c. SCIAPHLIA JAPONICA Mak. (after Ohga and Sinoto). — d. BUTOMUS UMBELLATUS L.

As previously stated, Wettstein (1924) from taxonomic considerations has shown that the Helobiae are the most simple and probably the most primitive of the monocotyledons. There are very good reasons for thinking that the Liliiflorae have been derived from this group. (Janchen, 1932). It is interesting to find that the very specialized chromosome constitution of 5 long and 25 short chromosomes, characteristic of the *Yucca-Agave* group, may well have had its origin in the Helobiae.

SUMMARY

Combining the results of previous workers with those of the present investigation, it has been possible to show that five genera in the Liliaceae (*Yucca, Hesperoyucca, Hesperaloë, Cleistoyucca, Samuela*) and four genera in the Amaryllidaceae (*Agave, Fourcroya, Polyanthes, Beschorneria*) form a distinct unit and as such should be united in any future revision of these two families. The evidence for this unity is based on geographic distribution, taxonomic and cytological similarities.

There is some evidence indicating that the heteromorphic chromosome set-up found in the *Yucca-Agave* group may be of general occurrence in the monocotyledons. *Hosta* in the Liliaceae has a chromosome complement identical with this group. Several species in the Helobiae have been shown to have a chromosome set-up from which that found in the *Yucca-Agave* group may have been derived.

The writer wishes to acknowledge the helpful criticism and suggestions of Professor Karl Sax and Dr. I. M. Johnston of the Arnold Arboretum, Harvard University.

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THE OCCURRENCE OF TUMORS ON CERTAIN NICOTIANA HYBRIDS

THOMAS W. WHITAKER

With plate 90 and one text figure

INTRODUCTION

TUMORS resembling, in some measure, the outgrowths found in plants infected with the crown gall organism are produced in great abundance by certain *Nicotiana* species hybrids. These curious outgrowths were apparently first described by Kostoff (1930), who carried out a series of experiments which led him to interpret the occurrence of the tumors as a manifestation of immunological activity.

Sufficient data have been accumulated to justify a re-analysis of the situation in respect to these spontaneous tumors and to suggest a plausible explanation for their occurrence on the basis of additional evidence.

The observations reported in this paper have been confined to F_1 plants secured by crossing *Nicotiana glauca* × *N. Langsdorffii*. Without exception plants of this genetical composition produced numerous tumors in some stage of their development.

The F_1 plants of this mating were approximately intermediate in appearance between the parental species. On the whole it may be said that there was little variation among the individuals of the F_1. Chromosome counts secured from root-tip preparations indicated that the chromosome number of these plants was 21. This is the number to be expected considering that the haploid numbers of *Nicotiana glauca* and *N. Langsdorffii* are twelve and nine, respectively. The reduction division in the pollen mother cells of these plants was extremely irregular. Pairing followed the Drosera scheme. Lagging, non-disjunction and other irregularities were frequently observed. The percentage of pollen sterility was very high (96%). Numerous attempts to self-fertilize the F_1 plants resulted in complete failure. Back-crosses to both parental species, utilizing the F_1 as either male or female, have also given negative results. It was not surprising that selfing was unsuccessful in view of the high pollen sterility. Evidently some of the ovules were viable, as Kostoff (1930) obtained back-crosses to *N. Langsdorffii* by employing the F_1 as the female parent.

LOCATION OF THE TUMORS

The tumors emerge on the stem from the axillary leaf bud. Occasionally, they may emerge from the entire leaf scar area. A careful examination of a number of plants has shown that the tumors rarely, if ever, emerge from the internodal spaces of the stem. Repeated attempts to induce tumor formation by scratching and wounding the surface of the stem at locations between leaf scars have thus far failed to induce tumor formation. It has been noted on several occasions that pinching back on the terminal bud seems to stimulate tumor formation by forcing the growth into the lateral, axillary meristematic regions.

Tumors appear to be produced with equal facility on roots or stem. However, in the plants examined, the tumors were more numerous on the stems than on the roots of the plants. In this connection, it is interesting to note that on the stems of the plants under observation, the tumors were emerging from each of the axillary buds from which the leaf had fallen off.

EXTERNAL AND HISTOLOGICAL FEATURES

In external appearance the spontaneous tumors are quite similar to the malformations produced by plants infected with the crown gall organism (Plate 90). When growth is formed into the tumors by pinching or cutting back of the main stem of the plant, a number of young shoots arise from the tumors producing the typical "witches' broom" appearance. It has been observed that the shoots produced in this fashion were identical with the mother plant (judged by external characteristics).

The more or less disorganized tissue making up the greater part of the bulk of the tumors is constituted primarily of parenchymatous cells, associated with scattered vascular elements. As the surface of the tumor is approached one finds numerous small, active meristematic areas. There is a rather thick covering of epidermal hairs over the surface of the tumorous regions.

In common with other malformations of a similar nature, the tumors found on the F_1 plants were characterized by an abundant accumulation of starch and tannin. The starch accumulation was chiefly localized in deposits of large oval masses, occupying an entire cell or in some cases two or three adjacent cells. There is also a considerable quantity of starch grains scattered throughout the entire mass of tumorous tissue. The quantity of starch and plastids in tumorous tissue is very much greater than in normal stem tissue. In comparing the histological features of tumorous tissue with normal stem tissue

one is primarily impressed by the lack of regularity of the former tissue. The scattered vascular elements, isolated starch storage cells and large meristematic surface all serve to heighten the impression of irregularity of the tumor tissue.

PHYSIOLOGICAL CHARACTERISTICS

The evidence on some of the more important physiological characteristics of these tumors can be summed up rather briefly:

1. Inoculation experiments have failed to transmit the causal factor or factors to other organisms. Various species of *Nicotiana* were used in attempt to transmit the causal factor from organism to organism (Kostoff, 1930).

2. It was found to be impossible to isolate bacteria or other parasites from the tumors, although several media were used in culturing attempts (Cleveland, from Kostoff, 1930). It should be pointed out that negative results from inoculation experiments and culturing attempts are merely indicative that parasitic organisms were not present but are not positive proof of this condition.

3. The causal factor cannot be transmitted across the graft union. Heteroplastic grafting, using the F_1 in combination with both parent species, utilized as both stock and scion, have failed to transmit the causal factor across the graft union. In combination with other species of *Nicotiana* (*N. Tabacum, N. paniculata*), the F_1 (*N. glauca* × *N. Langsdorffii*) has not been able to transmit the tumor-inducing agent across the graft union. Thus it seems abundantly proved that the tumors cannot be induced in either of the parent species, or in the two other species of *Nicotiana* used in the experiments, by means of grafting.

4. In the plants under observation the tumors developed on the roots during the early seedling stage. Tumors usually begin to appear on the stem during the flowering period, and once tumor formation is initiated, it continues throughout the remainder of the plant's life. In one family of F_1 plants there were five individuals which appeared to have symptoms of tumor on the stem at a very early age. These plants did not develop past the rosette stage and made no attempt to send up a flowering shoot but continued to produce sessile leaves in a crowded fashion, upon a much reduced stem. Root-tip counts of the chromosomes of these plants showed them to be 21 in number, similar to sister plants which were not deformed.

In connection with time-development, it is well to note that as long as the plant is in active growing condition and the terminal meri-

stematic region is active, tumors do not occur on the stem. When the plant has reached a certain physiological age and meristematic activity in the tip region has ceased, this activity is transferred to the lateral axillary buds, and tumor formation begins. The time when the plant begins to flower usually coincides with the time at which terminal meristematic activity ceases and tumor formation is initiated.

5. The tumors are apparently not malignant, at least not in the ordinary sense. Plants having tumors have been kept in good condition for over a year without any particular attention. These plants have never flowered after the initiation of tumor formation but the vegetative growth does not seem to have been impaired.

KARYOLOGICAL OBSERVATIONS

The chromosome number of the cells making up the tumorous areas of the plant can be very easily and quickly determined by the aceto-carmine smear maceration method. The technique used is the same as that employed in making root-tip smears (Whitaker, 1934), except that in making smears of tumor tissue, it is preferable to bring the material to boil in aceto-carmine before smearing. The latter treatment is a distinct aid in obtaining satisfactory maceration of the tissue.

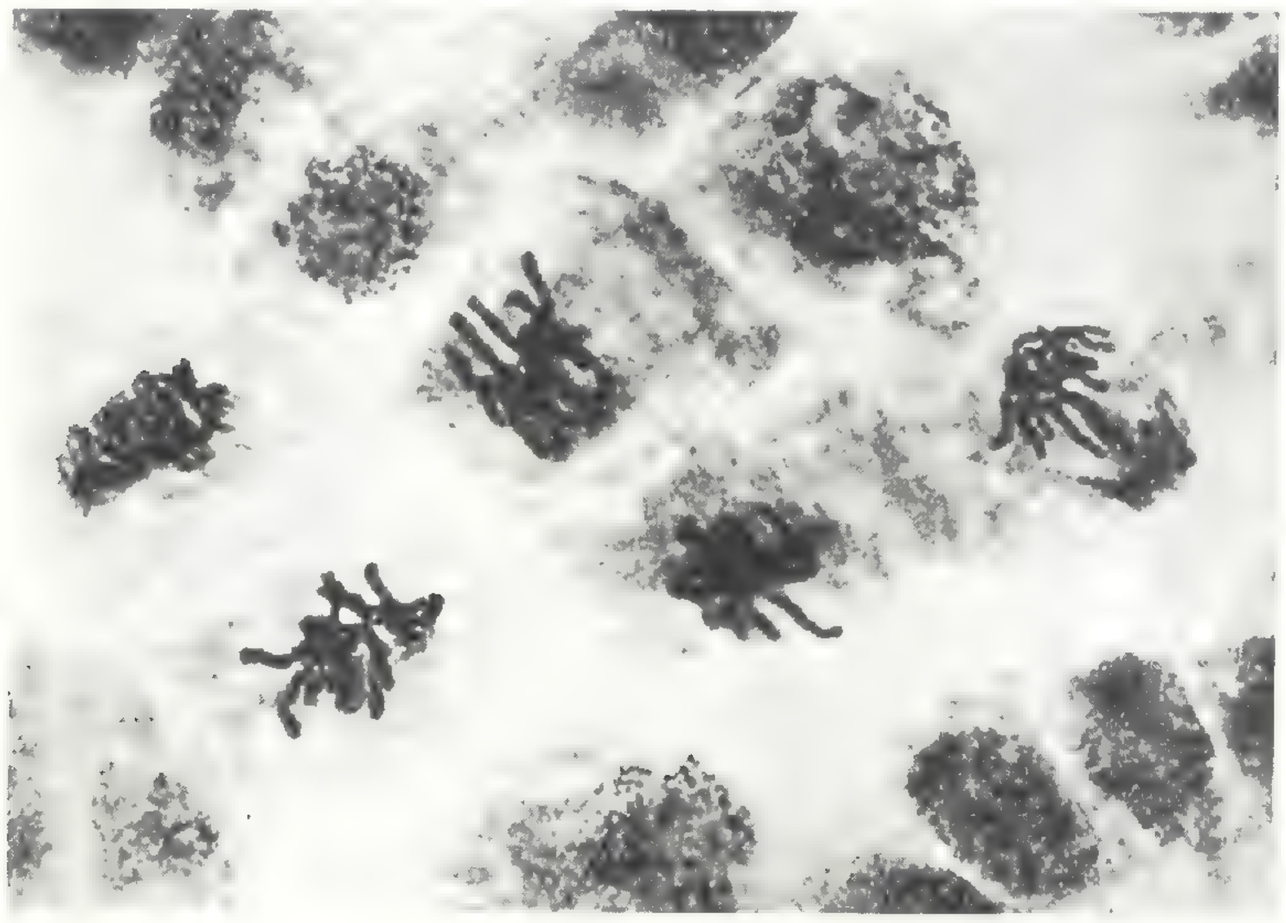


FIGURE 1. Microphotograph of an aceto-carmine smear of tumor tissue ($\times$ 2000). The number of cells in various stages of mitosis indicate the active state of reproduction often found among the cells of the meristematic areas.

The chromosome number situation is interesting in view of the findings of Winge (1927) in crown galls produced by *Bacterium tumefaciens* on the sugar beet. Winge has made observations which seem

to indicate that the majority of the tumorous cells are polyploid. He has interpreted this evidence as supporting the hypothesis that tumors result from somatic polyploidy.

The chromosomes in over 40 cells of the tumorous tissue have been counted, and not a single polyploid cell was found. Occasional tetraploid cells have been encountered in other slides but these are undoubtedly very rare.

Mitosis in cells of the tumor tissue seemed to be very regular; there was seldom any pronounced lagging or other irregularity (Text fig. 1). The few irregularities that have been found have not been considered significant.

In examining cells making up the tumor, particular attention was devoted to the nucleus in the hope of detecting karyological abnormalities which might possibly give some clue to the solution of the problem. The percentage of polynucleated cells is almost negligible. Three or four cases of double nucleated cells were recorded, but in only one of these cases could it be positively demonstrated that two nuclei were present in the same cell.

The status of the nucleolus in the tumorous tissue does not vary significantly from that of normal stem tissue. In the normal stem tissue, nuclei with as high as four nucleoli have been observed. Variations within this number have also been found in tumor tissue. The majority of the nuclei in tumor tissue seem to have two nucleoli.

DISCUSSION

In view of these observations, three possible causes of tumor formation have been considered.

1. IS THE CAUSAL FACTOR A VIRUS, BACTERIUM OR OTHER MICROORGANISM? This question is most effectively answered by the grafting experiments. It will be recalled that in these experiments, efforts to transmit the causal factor by grafting were unsuccessful. Many of the known viruses are readily transmissible across the graft union. (Heald, 1926). Further support against the supposition that the causal factor may be a virus is evident from the appearance of the plants which do not exhibit any of the typical known virus symptoms.

The inoculation experiments seem to rule out the possibility of the causal factor being in the nature of a bacterial or fungal parasite. Microscopic observation of both fresh and fixed material points in the same direction; namely, that bacterial and other parasites cannot be regarded as the responsible agents in tumor formation.

2. THE IMMUNOLOGICAL INTERPRETATION. This solution of the cause of spontaneous tumor formation in *Nicotiana* species hybrids has

been advocated by Kostoff (1930). His critical evidence in favor of this view is the "precipitin reaction" occurring between the parent species. The immunological significance of this reaction has been discussed (Chester and Whitaker, 1933). It is sufficient to state that this is not a critical test.

This is a difficult hypothesis either to prove or disprove. The only fact bearing on this question, and it is in no sense critical, is that *N. Langsdorffii* can be used as both stock and scion in graft combinations with *N. glauca*. They appear to be a fairly compatible graft combination. One would think that if species specific substances were diffused by each graft partner, the combination would be an extremely temporary affair. Such is not the case. These combinations are as long-lived as comparable, known compatible combinations and show no ill-effects from their intimate association.

Although the immunological interpretation cannot be eliminated by any of the known facts at the present time, it is a little difficult to visualize a system by which it would work in this instance. It might be possible that if it were an antigen-antibody reaction, the effect would be to limit the hybrid embryo to a few cell divisions, as McCray (1933) has found to be the case in some *Nicotiana* hybrids.

3. A CYTOPLASMIC DISTURBANCE CAUSED BY THE INTRODUCTION OF THE MALE CHROMOSOME COMPLEMENT. In this interpretation of the cause of tumor formation, the assumption is that the disturbance produced by the nine chromosomes of *N. Langsdorffii* in the cytoplasm of *N. glauca* is directly responsible for uncontrolled growth in certain tissues of the plants. This uncontrolled growth is exhibited externally by the tumors. An examination of the evidence indicates that this theory has some merit.

The first essential to have in mind is that the tumors are produced only when *N. glauca* is used as the female parent and *N. Langsdorffii* as the male parent. The reciprocal cross, although difficult to make, has been obtained by McCray (1932). The plants were very vigorous, and there was considerable variation among them. Even though there was a marked amount of variation among the F_1 individuals there was no reason for thinking that this was not a legitimate F_1 between the two species. From this work it seems to be clear that a reciprocal F_1 has been produced (*N. Langsdorffii* used as the female), and tumors were not present (McCray, private correspondence).

Theoretically if a back-cross to either species could be obtained, it should yield critical data on the validity of the proposed explanation. Back-crosses to the *N. Langsdorffii* parent have been made by employ-

ing the F_1 as the female parent (Kostoff, 1930). The progeny of such a mating should all possess tumors in a greater or less degree, since in such a system of matings no *N. Langsdorffii* cytoplasm has been introduced. It is not clear from Kostoff's description of the progeny of this mating whether all the plants had some indication of the disturbance. Apparently the majority of them had fasciations, which appear to be a milder expression of the disturbance than the spontaneous tumors. A smaller number of these plants had tumors, reported to be as large and as numerous as the tumors formed on the F_1.

The time of development does not offer serious difficulties in the path of the above explanation. The tumors are present in the very early seedling stage, at least on the roots. They were first visible on the stem about the time of flowering. If the effect is that of chromosomes upon cytoplasm, one would rather expect that it would exert a continuous influence from the earliest divisions following fertilization on through the life of the individual. The first indication of spontaneous tumors occurs in the roots where they are found shortly after germination. This seems to indicate that there is a continuous expression of the disturbance from immediately after germination on through the remainder of the life of the individual.

We have examined the evidence bearing on the explanation of tumor formation in the F_1 of *Nicotiana glauca* × *N. Langsdorffii*. How does this fit in with other cases of tumor occurrence reported in hybrid Nicotianas?

The cases in which tumors have been reported are listed in Table I.

TABLE I

	Chromosome No. (n)			Chromosome No. (n)	Investigator
N. quadrivalvis	24	×	*N. Sanderae*	9	Holmes (private correspondence)
N. rustica	24	×	*N. Sanderae*	9	Kostoff
N. Tabacum wigandioides	24	×	*N. Sanderae*	9	Kostoff
N. paniculata	12	×	*N. Sanderae*[1]	9	Kostoff
N. paniculata	12	×	*N. Langsdorffii*	9	Kostoff
N. rustica	24	×	*N. Langsdorffii*	9	Kostoff
N. rustica	24	×	*N. alata*	9	Kostoff
N. Tabacum sanguinea	24	×	*N. alata*	9	Kostoff

[1] *N. paniculata* × *N. Sanderae* must be considered as a doubtful case for the reason that the tumors did not appear on the stems, and it was questionable whether there were tumors present similar in nature to the cases cited above. Moreover, Christoff (1928) has produced this same F_1 combination, and in describing the plants, he makes no mention of the occurrence of tumors.

It is evident, from an inspection of Table I, that, in the combinations producing tumors in the F_1, the alata-group (*Nicotiana alata*, *N. Sanderae*, and *N. Langsdorffii*) having nine chromosomes is always involved as the male parent. There is one possible exception that should be mentioned. Kostoff (1930) records the F_1 hybrid of *N. rustica humilis* × *N. Tabacum sanguinea* as producing malformations, causing it to be placed with the tumor-producing hybrids of *Nicotiana*. It is distinctly questionable whether it belongs in this category. Tumors were not present on the stem or if present were not noticeable. A slight fasciation was produced which may or may not have been similar to the fasciations produced by the truly tumorous F_1 hybrids. The argument advanced above may well serve to account for tumor formation until more information on the progeny of this cross is available.

The explanation of tumor formation that has been offered, in which the cause has been assumed to be the disturbance originating from the introduction of *N. Langsdorffii* chromosomes into *N. glauca* cytoplasm, can be very easily extended to include the alata-group. The evidence presented in Table I signifies that the same forces are at work in this group of F_1 species hybrids as were found in the F_1 progeny of *N. glauca* × *N. Langsdorffii*.

In cases where reciprocal crosses have been obtained (alata-group used as the female parent) tumors have not been recorded as being present on any of the plants. For the reason that it is somewhat easier to secure crosses in which the species with the higher chromosome number is used as the female parent, most of the reciprocal crosses have not been successful, but where it has been possible to secure fertile crosses and hybrids brought to maturity, tumors were not reported in the description of the F_1 plants. The two cases where reciprocals have been obtained are: *Nicotiana Langsdorffii* × *N. Tabacum* and *N. Sanderae* × *N. Bigelovii* (from East, 1928). The fact that tumors were not recorded by the observers cannot be taken as absolute proof that they were not present, but there is the greatest likelihood that if tumors were present they would have been at least mentioned. It, therefore, seems safe to assume that these reciprocal F_1 hybrids were devoid of tumors.

One major criticism that can be made of the cytoplasmic disturbance theory, when applied to the three species belonging to the alata-group, is that the reactions of all three species are not the same when mated to a common species as far as the production of tumors is concerned. As an example of this point, take the cases where *Nicotiana glauca*

has been used as a female with *N. alata, N. Sanderae,* and *N. Langsdorffii.* In the first two cases the F_1 does not produce tumors. In the last case the F_1 produces tumors in great abundance. If we were dealing with a comparatively simple phenomenon, it seems reasonable to expect that all of the alata-group, when mated to a common species (*N. glauca*), would have similar reactions. That such is not the case has been pointed out above.

The evidence is fairly conclusive that when the 9-chromosome group of *Nicotiana* is introduced by the pollen parent into the cytoplasm of certain other *Nicotiana* species, there occurs a loss of control of growth by the organism in the meristematic areas. As a result of uncontrolled growth, tumors appear first on the roots and later on the axillary buds of the stem.

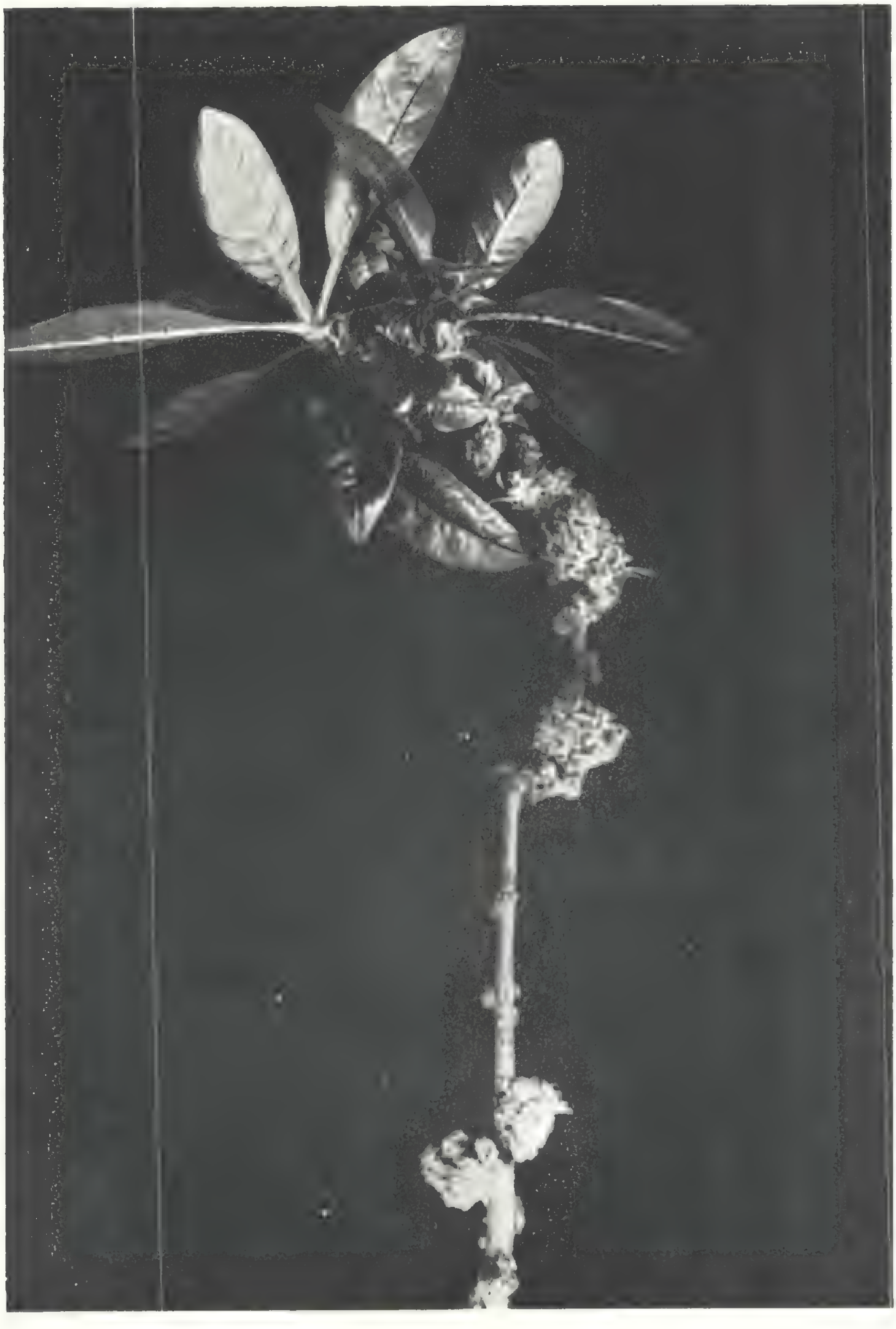
SUMMARY

1. Spontaneous tumors occurring on F_1 species hybrids between *Nicotiana glauca* and *N. Langsdorffii* have been studied from several different viewpoints in an attempt to discover the underlying causes for their occurrence.

2. All the available evidence indicates that the tumors are the direct result of a cytoplasmic disturbance. The disturbance is occasioned by the introduction of the chromosome complement of *N. Langsdorffii* (used as the pollen parent) into the cytoplasm of *N. glauca* (used as the seed parent).

3. The reported cases of spontaneous tumors in the F_1 of species hybrids of *Nicotiana* have been analyzed. All of them seem to be due to a cytoplasmic disturbance caused by the introduction of the chromosomes of the alata-group (*N. alata, N. Sanderae,* and *N. Langsdorffii*) used as the male parent into the cytoplasm of certain other Nicotianas (*N. glauca, N. paniculata,* etc.) used as the female parent.

I am very grateful to Professor E. M. East of Harvard University for certain suggestions regarding interpretation and for critical reading of the manuscript.



Tumors on Nicotiana Hybrids

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EXPLANATION OF PLATE 90

Main branch of an F_1 hybrid between *Nicotiana glauca* and *N. Langsdorffii* about one year old showing the frequent occurrence of spontaneous tumors.

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[1]A recent publication by Kostoff (Tumor problem in the light of researches on plant tumors and galls and its relationship to the problem of mutation. Protoplasma, **20**:440-456, 1933) came to hand after the completion of this manuscript. It is simply a review of his previous work, with an attempt to homologize spontaneous plant tumors with malignant tumors of animals (cancers). No new data have been presented. The interpretation is the same as in the previous work.

NOTES

Blister Rust of Pinus longifolia Roxb. — Blister rust diseases of pines rank among the most important of tree diseases. They are known on both hard and soft pines throughout the northern hemisphere. Most are caused by heteroecious rust fungi and with few exceptions the causal organisms are incapable of passing directly from pine to pine. Several have received considerable study, but comparatively little is known about the majority of them. The most exhaustive investigations have been made on the highly destructive blister rust of 5-needled pines caused by *Cronartium ribicola* Kleb., and for its control eradication of *Ribes* has been thoroughly demonstrated as an effective measure. There now comes from the pen of Dr. K. Bagchee, Mycologist of the Forest Research Institute at Dehra Dun, India, the second part of an account[1] of comprehensive researches carried out by him on a hitherto little-known blister rust of "chir," a 3-needled pine (*Pinus longifolia* Roxb.), which is destructively prevalent in some of the forests of northern India, particularly in the pine forests of the Kumaon and Garwhal Himalayas. Dr. Bagchee's paper is reviewed below and to the review is added a brief comment on the nomenclature applied to the causal fungus. The quotations cited are from that paper unless otherwise indicated.

Pinus longifolia is regarded as "one of the most important forest trees in the Himalaya." Its wood is employed for ordinary furniture, general carpentry, heavy timber of all sorts, railway ties, resin production, and to some extent as fuel. "This pine is also of considerable importance as a park, garden, avenue and ornamental tree."

Barclay appears to have been the first to make mention of the fungus on chir that causes blister rust. In the opening paragraph of his description of *Aecidium complanatum* nov. sp. on *Pinus longifolia* Roxb. Barclay commented, "I have only once seen it on the stem (var. *corticola*) and my further remarks refer only to the variety on the needles." (BARCLAY, A. A descriptive list of the Uredineae occurring in the neighborhood of Simla [Western Himalayas]. Pt. III. Jour. Asiatic Soc. Bengal, **59**:101. 1890.) Reports of death of young chir trees, causes undetermined, began to issue in 1891; but it was not

[1] BAGCHEE, K. Investigations on the infestation of Peridermium himalayense Bagchee on Pinus longifolia. Part II. Cronartium himalayense, n. sp., on Swertia spp. Distribution, morphology of the parasite, pathological study of the infection, biological relationship with the pine rust, and control. (Indian Forest Records, **18**:1-66, front., pl. 1-17. 1933.)

until 1915 that blister rust "was definitely recorded as apparently doing much damage." According to Dr. Bagchee the causal fungus is seemingly native to the inner valleys of the Himalayas, and he believes that it later spread to the outer ranges. Earlier accounts referred to above, indicated sporadic outbreaks "in some of the chir forests of Kumaon," but now there is "a typical widespread epidemic involving heavy loss in the young pine stands in the Kumaon and Garwhal Himalayas."

The attack of this disease, both in plantations and natural forests, is on young trees (seedlings and saplings) up to 20 years of age. "The heaviest infection occurs on young plants 2 to 3 feet high" (Part I.) "Trees beyond 20 years of age appear safe from infection." It is of interest to note that even very young seedlings are susceptible; successful inoculations were made on seedlings between one and two years of age. "Such plants died within one year after inoculation and histological examinations showed the presence of numerous hyphae and haustoria in the cambium and cortical cells." Indeed, death of these plants ensued before there was time for the fungus to form aecia. So far as could be determined "healthy and vigorous regeneration is as much open to such danger as plantation crops," and the disease is not one which is more particularly restricted, as some foresters have maintained, to weak or suppressed plants. The amount of damage suffered in the pine forests of the Kumaon and Garwhal Himalayas has not been statistically estimated, but is considered to be very great. As extreme instances Dr. Bagchee informs us that in one locality examined carefully by him the disease had killed 60 percent of the saplings and of the remaining 40 percent scarcely any were free from infection; in the Almora Forest Division the mortality of young seedlings left wide gaps in the stand, and attempts to fill these by occasional sowings had failed because of the wholesale destruction of seedlings as rapidly as they appeared. "The increase in the rate of mortality as a result of the attack of this bark-inhabiting fungus pest, has threatened to wipe out the pine in the plantations close to Almora." (Part I.)

The lesions caused are stem cankers and are accompanied by little or no swelling. They closely resemble the lesions caused by *Cronartium Comptoniae* on such a pine as *P. Banksiana*. "Under the attack of the parasite the plant dries up and finally dies from the girdling of the stem" (Part I.). The youngest hosts are killed rapidly, but on older ones, according to their age, the cankers persist for from two to many years, spreading from year to year until girdling is completed.

One of the objectives projected by Dr. Bagchee was a determination of the life history of the causal organism. After long, discriminating search a *Cronartium* was discovered on three species of *Swertia* (a genus of the Gentianaceae), annual herbs widely distributed on the forest floors in the affected regions, namely, *S. angustifolia, S. alata* and *S. cordata*. Then followed a series of sound, painstaking experiments, often impeded because of unforeseen technical difficulties, that culminated in ample, positive demonstration of the fact that the blister rust fungus alternates between *Pinus longifolia* and any one of the three species of *Swertia* named. We now have a picture of the life cycle of the blister rust fungus, adequate in its general outlines, and complete in many of its details. The spermogonia emerge in the pine during October or November, not sooner than the year following infection, the incubation period being variably protracted. "The aecidial stage may appear in the following spring or a year later on the same parts of the plant where pycniospores were detected during the previous autumn." A copious crop of aeciospores is produced and they may be wind-borne for very long distances. Infection of *Swertia* takes place immediately, and in from 9 to 15 days after inoculation uredospores are evident. "As in *Cronartium ribicola,* so with this fungus, there is a successive series of uredospore productions which are again followed by a similar series of teleutospore crops. In 1927 when this fungus was first noticed in Kaligadh seven series of uredospore crops were counted. This was succeeded by a mixed crop of both uredo and teleutospores till the end of October. * * * As compared with the uredosori, the teleutosori are produced in relatively greater abundance with each succeeding generation. Up to six distinct waves of teleutospore crops were counted in 1927, and about three crops in 1928." The teliospores germinate promptly *in situ* and the basidiospores are disseminated by air currents, just as is true of the dissemination of aeciospores and uredospores. Exact data on the effective ranges of uredospores and basidiospores have not yet been obtained, but the author arrives at the tentative conclusion that "600 yards for uredospores and 200 yards for sporidia may be taken as the preliminary working distance for control measures." Since the *Swertia* plants die in the fall and neither uredospores nor aeciospores so far as could be determined overwinter in a viable condition the fungus is apparently carried over solely by the perennial mycelium in the cankers on the pines.

Considerable space in the paper under review is given over to a discussion of possible control measures. The author dismisses all

except that of eradication of *Swertia* as being impracticable or of relatively little value. Some observational evidence is adduced in support of these opinions. "Eradication of the alternate host is recommended as the only suitable measure to deal with this disease effectively. * * * A scheme has been suggested for the eradication of *Swertia* spp. for three years in succession and thereafter in alternate years for six eradication years in Periodic Block I areas. The best time for eradication operations is soon after the rains till early autumn, before the *Swertia* seeds mature and are dispersed."

Dr. Bagchee fully describes the causal fungus and chooses to call it *Cronartium himalayense*, sp. nov. "in uniformity with the aecidial stage" which he had previously described under the name *Peridermium himalayense*, a name which he considers particularly appropriate because of the Himalayan native habitat. He reduces to synonomy *Uredo Opheliae* Sydow, a name based on the uredo phase and published with description by H. and P. Sydow in 1903. *Ophelia* is a subgenus of *Swertia*. Based on the claim of greater appropriateness the choice of *C. himalayense* is, of course, not permissible according to international rules of nomenclature. A more valid claim could be advanced because the teliospores are described here for the first time. Many competent mycological taxonomists, however, in their interpretation of the rules, maintain that names based on the uredo phase given prior to names based on the telial phase retain priority. This view is reasonably based. In my judgment, therefore, the correct name of this fungus is **Cronartium Opheliae** (Sydow), n. comb., with synonyms *Aecidium complanatum* Barclay var. *corticola* Barclay (without description), *Uredo Opheliae* Sydow, *Peridermium himalayense* Bagchee and *Cronartium himalayense* Bagchee.—J. H. FAULL.

Wehmeyer's "The Genus Diaporthe Nitschke and its Segregates"—The taxonomic literature of mycology has been piling up apace during the long period of years from Persoon and Fries onward, a constantly mounting mass of descriptions of myriad fungus species. Much of it never satisfactory, the difficulty of using it increases as the unceasing cumulating process continues. This is not a necessary attribute of volume because if the unit constituents are properly depicted and properly named, a directory of Linnean quality to point the way clearly throughout can be formulated. The two outstanding defects are inadequacy of many of the descriptions and interspersion of undetected aliases. The former is referable to scanty material or lack of knowledge of diagnostic characters in phases of life cycles often not

yet determined, and sometimes simply to hurry, carelessness or incompetence. Unwarranted multiplication of names is the result of another set of causes. In the appraising of supposedly new species taxonomists have without justification created new names, some because they have overstressed host affiliations, others because they have been unduly influenced by erroneous conceptions of geographical restriction, or have lacked necessary library facilities, or more often still have not been familiar with the type materials of pertinent groups. What a boon to the subject it would be if types or portions of types were stored in designated emporiums, emporiums in one or another of which the deposition of type material would be a requirement to the establishment of nomenclatorial priority, not less so than the writing of Latin descriptions.

That mycological taxonomic literature is in need of subjection to a 'purification process," especially with respect to an improvement of descriptions and a weeding out of synonyms masquerading as principals, is obvious. It is true that this has already been done for a comparatively few genera or groups of allied genera, but for the main part these are small or geographically limited in their distribution. The most ambitious accomplishment is represented by Sydow's monumental Monographia Uredinearum. But the great mass still remains untouched. It is with joy, therefore, that we hail the appearance of every contribution to the purifying process. A work of this kind has just come from the hand of its author; I refer to a monograph on "The Genus Diaporthe Nitschke and its Segregates" by Dr. Lewis E. Wehmeyer of the University of Michigan.

This work, published as a book of 347 pages and 18 full-page plates, is issued (1933) from the University of Michigan Press, Ann Arbor, as Volume IX of the Scientific Series, University of Michigan Studies. The volume is large octavo size, beautifully printed on good paper and well bound. The University of Michigan Press is to be congratulated on the excellence of the workmanship throughout, and the editor on the choice of format and care in proofing.

The genus *Diaporthe* is a large, but compact caulicolous group of fungi, world-wide in distribution. Most species occur on woody stems. A few are known to be parasitic and there are indications that several others may be weakly so. More than 650 species names are in existence; they are accompanied by descriptions, poor, good and all grades between; some are based on morphological characters, others virtually on host relationships. They owe their being to about 110 authors. A number of the types cannot be located, and it is safe to say that the

rest are scattered far and wide, some treasured in readily accessible herbaria, private or institutional, others in out-of-the-way places and variously housed. As a topic for monographic treatment *Diaporthe* is not more interesting than many others, nor is it less so. None is surely in much greater need of revision, and few present a more formidable undertaking.

Dr. Wehmeyer's preparations for the undertaking were laid with care and thoroughness. He devoted himself during a long period of years to foundation studies on the morphology, life histories and host relationships of representative species of *Diaporthe* and extended some of his studies to similar genera. Portions of the results were published from time to time, a series of valuable papers. They comprised such papers as "The imperfect stage of some Pyrenomycetes obtained in culture" (1923), "Cultural life-histories of certain species of Eutypella, Diatrypella and Cryptovalsa" (1925), "A biologic and phylogenetic study of the stromatic Sphaeriales" (1925), "Further cultural life-histories of the stromatic Sphaeriales" (1926), "Cultural life-histories of Diaporthe" (4 papers, 1926-1929), "Studies on the rôle of the host in the genus Diaporthe" (1930). It is especially worthy of note that he gave close attention to the topic of host restrictions and that he worked out the life histories of 26 species of *Diaporthe* or its segregates. His preparation, therefore, resulted not only in important extensions to our knowledge of these fungi, but also enabled him to become widely acquainted with the materials of his subject and to orient himself on sound principles to be applied in making a taxonomic revision.

The introductory chapter of Dr. Wehmeyer's book is well written, comprehensive and at the same time concise. He discusses his treatment of the genus, explains the morphology and development characteristic of the genus, defines descriptive terms employed, points out the peculiarities of the segregates, gives a picture of the distribution and closes with a key to the genera. Space does not permit reference to the many interesting points dealt with in this introduction. Certain features, however, should be noted. Thus in his treatment, "species are separated on purely morphological grounds," whereas "the general practice in the past has been to describe as a new species every occurrence on a new host genus, regardless of the similarity of the morphological characters." "Under each morphological species which appears on a number of hosts a description of the occurrence and a synonymy of each of the host forms are given." The conidial stage of *Diaporthe* proper proves to be *Phomopsis* (as limited by Diedicke) or Phomopsis-

like, but for the segregates other forms are represented. With regard to the diagnostic value of stromatic and conidial characters he re-affirms earlier conclusions, namely, (1) "stromatic characters are likely to be more plastic and variable than conidial characters; on the other hand, certain tendencies or differences in range of variation of stromatic characters may be quite constant and characteristic, and when correlated with the host may indicate definitely separated species"; (2) conidial size and shape for a particular species appear to be quite constant regardless of substratum; (3) "specific separations on slight morphological differences in the perithecial stage often become more pronounced when the imperfect stage is known"; (4) "morphological differences in both the perithecial and conidial stages are often definitely correlated with the host, indicating that closely related species with slight morphological differences are often definitely limited as to their host species under natural conditions" (1930). "All citations of hosts, distribution, and exsiccati * * * are based upon material actually examined by the writer."

The introduction is followed by chapters with the following headings—*Diaporthe* Nit. emend. (pp. 14-188), *Cryptodiaporthe* Petrak emend. (pp. 189-215), *Diaporthella* Petrak (pp. 216-218), *Apioporthe* Höhn. emend. (pp. 219-227), *Diaporthopsis* Fabre (pp. 228-234), Doubtful Species (pp. 235-241), Excluded Species (pp. 242-271), Species Not Seen (pp. 272-334); and the work ends with an excellent index of genera and species; it would have helped were the hosts also listed or a separate host index prepared. The chapters on the various genera are prefaced by carefully constructed keys. The results of the purifying process with respect to the number of species accepted and the disposition of them is startling. Sufficient data were not available to enable him to be certain of 18 of the species; they are placed in a chapter by themselves and described as well as possible. Eighty-seven are excluded altogether; these, too, constitute the subject matter of a chapter; with reasons assigned they are properly referred wherever possible. The most startling feature is the drastic reduction of names to synonymy; in all, upwards of 350 species names are so reduced. As striking instances I note 118 synonyms for *Diaporthe eres*, 34 for *D. Arctii*, 22 for *D. pardalota* and 21 for *D. medusaea*. The count of accepted species shows 71 for *Diaporthe* (6 of which are new), 19 for *Cryptodiaporthe*, 3 for *Diaporthella*, 8 for *Apioporthe* (1 new), and 6 for *Diaporthopsis* (1 new). The reviewer has not taken time to check on author's adherence to the international nomenclatorial rules. One important deviation was noted in the case of *D. medusaea;* two older

names are rejected, one (*D. rudis*) because of "absence of type material," the other (*D. faginea*) because it "gives the wrong impression of this collective species." The latter does not seem a sufficient excuse for violation of the rules. The closing chapter deals with species not seen, 148 all told. Persistent and time-consuming as have been Dr. Wehmeyer's efforts he has not found it possible to see material of any of those species. Fifty-four of them are said to be reported from South America; presumably most of them are in Spegazzini's herbarium. Forty-one are from Italy; presumably most of them are in Saccardo's herbarium. The hope is expressed that the author will complete his undertaking, not resting until existing types of the "species not seen" are seen and made to pass through the purifying fire of his critical study.

In spite of its lack of completeness Dr. Wehmeyer has contributed to mycology a work of outstanding merit. There will not be universal acceptance of every one of his conclusions, partly because of honest differences of opinion as to just where lines should be drawn between species, and partly because added knowledge of life histories will demand revisions. But all mycologists will rejoice in the fact that the subject matter has been assembled, coordinated and presented in clear perspective. It will long remain as the standard work on *Diaporthe* and its segregates.—J. H. FAULL.

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THE HOSTS, LIFE HISTORY AND CONTROL OF THE CEDAR-APPLE RUST FUNGUS GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE SCHW.

IVAN H. CROWELL

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I. INTRODUCTION

Gymnosporangium Juniperi-virginianae Schw. and the diseases caused by it have long been known to mycologists and phytopathologists. *Gymnosporangium Juniperi-virginianae* was first described on *Juniperus virginiana* L. by Schweinitz in 1822 and on *Malus coronaria* Mill. under the name *Caeoma* (*Aecidium*) *pyratum* by the same author in 1832. Experimental demonstration of these as two phases of the same organism was made independently by Halsted and by Thaxter in 1886. Shortly after the results of their experiments were published (1887) eradication of the red cedars adjacent to orchards was recommended as a protection to apples. Their findings have been repeatedly confirmed and the eradication of red cedars as an effective protective measure has been proved and widely practised. It is almost solely from this point of view that *G. Juniperi-virginianae* has been regarded up to the present.

In recent years there have been persistent demands for information on *G. Juniperi-virginianae* with reference to the pathogenicity and control of this organism on various species of *Malus* employed as ornamentals and also on species of *Juniperus*, particularly the eastern red cedar. There has likewise been a recognition of the difficulties and disadvantages attendant on red cedar eradication, and growing out of that a demand for more satisfactory control measures. These desiderata have served as the stimulus that led to the investigations outlined in this paper.

The main lines of my investigations are as follows:

1. A determination by means of cultures of the species of pomaceous hosts susceptible to *G. Juniperi-virginianae*, and for those that are susceptible, their degree and their period of susceptibility.

2. Field observations on the susceptibility of species of *Juniperus* to *G. Juniperi-virginianae*.

3. A study of the geographical range and symptomatology of the diseases caused by *G. Juniperi-virginianae*.

4. A detailed inquiry into the life history of *G. Juniperi-virginianae* and a cultural study of biological strains.

5. Observations on factors influencing the amount of infection on the hosts of *G. Juniperi-virginianae*.

6. The testing of fungicidal control measures.

II. A DETERMINATION BY MEANS OF CULTURES OF THE SPECIES OF POMACEOUS HOSTS SUSCEPTIBLE TO G. JUNIPERI-VIRGINIANAE

Such knowledge as we have of the pomaceous hosts of *G. Juniperi-virginianae* as determined by cultures is due mainly to the work of Halsted, Thaxter, Pammel and Arthur. Halsted (1886) successfully cultured *G. Juniperi-virginianae* on *Malus coronaria* in 1886. Thaxter (1887) made successful cultures on *M. pumila* (*M. Malus*). He also inoculated *Sorbus americana, Aronia arbutifolia* (*Pyrus arbutifolia*), *Crataegus coccinea* and *Amelanchier canadensis* but with negative results. Pammel (1905) stated that he inoculated *G. Juniperi-virginianae* on *M. ioensis, M. ioensis* "Soulard Crab," *M. pumila* (*M. Malus*), *Crataegus mollis, C. pinnatifida, C. punctata, Sorbus Aucuparia, Pyrus communis* and *Amelanchier alnifolia.* He reported infection on *M. ioensis, C. mollis* and *C. pinnatifida,* but the inclusion of the two latter species as hosts of *G. Juniperi-virginianae* is open to question. Bliss (1933) also doubts the validity of these species as hosts. The photographs and descriptions of the fructifications on *C. mollis* and *C. pinnatifida* closely resemble *G. globosum* Farl. *Pyrus melanocarpa* = *Aronia melanocarpa,* has likewise been recorded as a host of *G. Juniperi-virginianae* (Plant Disease Reporter 12:71. 1928). I have examined the collection on which the report is based and find the fungus to be *G. clavipes* C. & P. I am not including these species as hosts of *G. Juniperi-virginianae.* All of the other species listed by Pammel remained free from infection. Arthur (1908, 1909) confirmed the work of Halsted and Thaxter as to *M. coronaria* and *M. pumila* respectively.

It will be seen from the foregoing that *M. coronaria, M. pumila* and possibly *M. ioensis* have already been culturally established as hosts of *G. Juniperi-virginianae.* Other workers have reported additional hosts from observations made in the field. Farlow (1880) reported that *M. angustifolia* was susceptible in Massachusetts. Kern (1911) added *M. baccata* to the list of known hosts. Haskell (1919) reported *M. floribunda* (*Pyrus pulcherrima*) as a host. Adams (1921) found that *M. glaucescens* was susceptible in Pennsylvania. Martin (1926, 1928) reported *M. spectabilis* var., also *M. Sargenti* and *M. arnoldiana* as hosts. Blain (1931) stated that *M. sylvestris* was also susceptible, and Bliss (1933) reported that "pycnidia formed occasionally" on *M. spectabilis* (*Pyrus spectabilis*). In addition to the *Malus* hosts Johnson (1909) reported *Pyrus communis* and Patterson (1922) reported *P. glauca,* but I cannot find a reference to such a species as the latter. The incorporation of *Malus baccata, M. floribunda, M. Sargenti, M.*

arnoldiana, Pyrus communis and *P. glauca* as hosts, however, are not in accordance with my findings. Further than these cultures and field observations, no authentic information is available as to the susceptibility of most of the species of the genus *Malus*. In order to fill this gap, an extensive series of cultures was made on as many species of *Malus* as possible. Fortunately all but two or three of the known species were available for testing in the Arnold Arboretum of Harvard University where this experimentation was exclusively conducted. Because of the fact that species of other genera were reported as hosts to *G. Juniperi-virginianae* (as noted above), the tests were extended to several other pomaceous genera. The complete list comprises 17 species and varieties of *Amelanchier*, 1 of *Crataegomespilus*, 1 of *Cydonia*, 75 of *Malus*, 1 of *Photinia*, 19 of *Pyrus*, 2 of *Sorbaronia* and 17 of *Sorbus*. One species of *Comptonia* and two of *Myrica* were also inoculated. In addition, field notes were made on all species of *Crataegus* (942) growing in the Arnold Arboretum.

The cultures in all instances were conducted on undisturbed trees in the Arnold Arboretum. Small branches were inoculated and the rest of the crown served as controls. In the inoculation work celluloid cylinders as described by Hubert (1916) were used, but in plugging them sphagnum moss was substituted for cotton. They made satisfactory and efficient moist chambers for spore germination on the trees under field conditions. A two ounce vaseline jar proved to be a convenient container for carrying the inoculum. The latter was applied to the plant parts by means of a camel's hair brush.

In preparing the inoculum the galls of *G. Juniperi-virginianae* employed were gathered fresh from red cedar trees or taken from a store in a refrigerator. The teliospores, when kept at approximately 4° C., remained viable for a period up to nine months. From twenty to thirty telia were plucked from the galls and dropped into tap or distilled water in the inoculum bottle. After the telia had become partially softened by gelatinization, a process requiring about five minutes, they were crushed against the side of the bottle with the finger and this provided a uniform suspension of the teliospores. The inoculum was then ready for use. It would remain in good condition for two to three hours after which a fresh lot was prepared. The first inoculations were made soon after the leaves emerged from the buds, and inoculations were repeated periodically on other leaves as long as they remained susceptible to infection.

For inoculating, a branch was selected and tagged and an abundance of inoculum was applied to the leaves, flowers or fruit and stem with the camel's hair brush. The twig was inserted in the inoculation tube

which was then plugged with wet sphagnum and tied to the underside of a nearby branch for support and to protect the enclosed twig from excessive heating by the sun. The tubes were left on the inoculated twigs for two or three days. With this technic positive results were almost certain if the hosts were inoculated while the young parts were still within their period of susceptibility. The heavy sowing of teliospores combined with a very moist atmosphere and cool temperatures gave almost optimum conditions for the germination of the spores.

In recording data the inoculated plants were classified according to five categories or degrees of relative susceptibility. These groups were designated by symbols and defined as follows:

0—immune, no fructifications formed.
s—only abortive spermogonia formed.
1—resistant, from one to five aecia per sorus.
2—moderately susceptible, five to twenty-five aecia per sorus.
3—very susceptible, twenty-five or more aecia per sorus.

A complete enumeration of all species and varieties of inoculated plants, and of four species of *Malus* (marked by *) not inoculated but examined for natural infection, on which the results were negative were as follows:

Amelanchier amabilis Wieg., *A. asiatica* Endl., *A. Bartramiana* Roem., *A. Bartramiana* × *laevis*, *A. canadensis* Med., *A. florida* Lindl., *A. grandiflora* Rehd., *A. humilis* Wieg., *A. humilis* × *sanguinea*, *A. intermedia* Spach., *A. laevis* Wieg., *A. oblongifolia* Roem., *A. ovalis* Med., *A. sanguinea* DC., *A. sera* Ashe, *A. spicata* K. Koch, *A. stolonifera* Wieg.

Crataegomespilus grandiflora Bean.

Crataegus (942 species) A complete enumeration will appear in an article by J. D. MacLachlan.

Cydonia oblonga Mill.

Malus arnoldiana Sarg., *M. asiatica* Nakai, *M. atrosanguinea* Schneid., *M. baccata* Borkh., *M. baccata costata* Hort., **M. baccata gracilis* Rehd., *M. baccata Jackii* Rehd., *M. baccata mandshurica* Schneid., **M. baccata microcarpa* Regel, *M. baccata pendula* Hort., *M. brevipes* Rehd., *M. flexilis* Hort., *M. florentina* Schneid., *M. floribunda* Sieb., *M. Halliana* Koehne *Parkmanii* Rehd., *M. Halliana spontanea* Rehd., *M. Hartwigii* Koehne, *M. honanensis* Rehd., *M. hupehensis* Rehd., *M. kansuensis* Schneid., *M.* spec. (*Pyrus Malus laurifolia* Gibbs), *M.* spec. (*Pyrus Lemoinei* Hort.), *M. magdeburgensis* Schoch, *M. micromalus* Mak., *M. orthocarpa* Lavall., *M. Prattii*

Schneid., *M. pumila* Mill., *M. pumila Niedwetzkyana* Schneid., *M. purpurea* Rehd., **M. purpurea aldenhamensis* Rehd., *M. purpurea Eleyi* Rehd., *M. robusta persicifolia* Rehd., *M. Sargenti* Rehd., *M. Scheideckeri* Zabel, *M. Scheideckeri "Excellenz Thiel," M. sikkimensis* Koehne, *M. spectabilis* Borkh., *M. spectabilis Riversii* Nash, *M. sublobata* Rehd., *M. toringoides* Hughes, *M. trilobata* Schneid., *M. Tschonoskii* Schneid., *M. yunnanensis* Schneid., **M. yunnanensis Veitchii* Rehd., *M. zumi* Rehd., *M. zumi calocarpa* Rehd.

Photinia villosa DC.

Pyrus amygdaliformis Vill., *P. Balansae* Decne., *P. betulifolia* Bge., *P. Bretschneideri* Rehd., *P. communis* L., *P. denticulata* Hort. Angl. ex Dum.-Cours., *P. elaeagrifolia* Pall., *P. Korshinskyi* Litv., *P. Lindleyi* Rehd., *P. longipes* Coss. & Dur., *P. Michauxii* Bosc, *P. nivalis* Jacq., *P. pashia* Buch.-Ham., *P. phaeocarpa* Rehd., *P. salvifolia* DC., *P. serotina* Rehd., *P. serrulata* Rehd., *P. syriaca* Boiss., *P. ussuriensis* Maxim.

Sorbaronia alpina Schneid. *superaria*, *S.* spec.

Sorbopyrus auricularis bulbiformis Schneid.

Sorbus americana Marsh., *S. Aria* Crantz., *S. arnoldiana* Rehd., *S. Aucuparia* L., *S. commixta* Hedl., *S. decurrens* Hedl., *S. discolor* Hedl., *S. dumosa* Greene, *S. hybrida* L., *S. intermedia* Pers., *S. japonica* Koehne *calocarpa* Rehd., *S. Matsumurana* Koehne, *S. Meinichii* Hedl., *S. pohuashanensis* Hedl., *S. rotundifolia* Hedl., *S. subpinnata* Hedl., *S. thuringiaca* Fritsch.

Other plants inoculated were *Comptonia asplenifolia* Ait., *Myrica carolinensis* Mill. and *M. Gale* L.

The results of the successful inoculations as well as examinations of plants in the Arnold Arboretum for natural infections show that the pomaceous hosts of *G. Juniperi-virginianae* were found in the genus *Malus* only (*Malus* as limited by Rehder 1927). These hosts were divided into two groups according to the degree of development of the aecial phase of the rust. These groups were A, those hosts that produced both spermogonia and aecia, and B, those hosts that produced spermogonia only.

A complete list of the pomaceous hosts of *G. Juniperi-virginianae* is presented in table I.

Studies of the hosts in groups A and B, as given in table I, reveal several interesting facts.

(a) A remarkable correlation is found to exist between the hosts in group A and their taxonomic position. Taxonomically, these hosts, with the exception of *M. fusca* and *M. sylvestris*, belong to the section

Chloromeles Rehd. of the genus *Malus;* indeed, they comprise all of the known species and varieties of that section.

(b) Another striking correlation is brought to light when the geographical distribution of the hosts in group A is taken into consideration, namely, it is found that these plants are native to North America only. In fig. 1 is shown an outline map of North America upon which the natural geographical distribution of these hosts has been plotted as vertical lines. It will be seen from this map and its accompanying description that, at the present time, the geographical distribution of *G. Juniperi-virginianae* extends completely over the coinciding ranges of the native species of *Malus* and the eastern red cedar. *Malus fusca,* native to the Pacific coast region of North America, and *M. sylvestris* of Europe, were the only species outside the section Chloromeles on which aecia were consistently produced. It is noteworthy, however, that *M. fusca* and *M. sylvestris* proved to be the most resistant species of group A.

TABLE I.

A COMPLETE LIST OF THE KNOWN POMACEOUS HOSTS OF GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE SCHW.

Group A, containing those hosts on which both spermogonia and aecia were produced.

	Degree of susceptibility		Degree of susceptibility
Malus		Malus	
angustifolia Michx.	2	ioensis Britt.	2
*arnoldiana Sarg.		**ioensis	
*baccata Borkh.		Palmeri Rehd.	3
bracteata Rehd.	2	ioensis plena Rehd.	3
coronaria Mill.	2	lancifolia Rehd.	2
coronaria		platycarpa Rehd.	2
Charlottae Rehd.	3	platycarpa	
coronaria		Hoopesii Rehd.	2
elongata Rehd.	2	*Sargenti Rehd.	
Dawsoniana Rehd.	1	Soulardi Britt.	3
*floribunda Sieb.		sylvestris Mill.	1
fusca Schneid.	1	Pyrus	
glabrata Rehd.	2	*communis L.	
glaucescens Rehd.	2	*glauca	

Also many orchard varieties of apples.

*These hosts were reported by other workers, but were not observed as susceptible in the Arnold Arboretum.
**Observed from herbarium material in the Arnold Arboretum.
1—resistant, from one to five aecia per sorus.
2—moderately susceptible, from five to twenty-five aecia per sorus.
3—very susceptible, from twenty-five or more aecia per sorus.

Group B, containing those hosts on which spermogonia only were produced.

Malus
adstringens Zabel
astracanica Dum.-Cours.
prunifolia Borkh.
prunifolia
fastigiata Rehd.
prunifolia fructu coccineo
prunifolia rinki Rehd.
*pumila Mill.

Malus
pumila apetala Schneid.
pumila pendula
"Elise Rathke"
robusta Rehd.
Sieboldii Rehd.
Sieboldii arborescens Rehd.
Sieboldii × spectabilis
*spectabilis Borkh.

(c) Equally striking correlations are found to exist between the hosts in group B and their taxonomic position and geographical distribution. In table II are presented certain data on the hosts on which spermogonia only were produced. An examination of column two of this table will show that taxonomically all of these hosts are restricted to the sections Eumalus Zabel and Sorbomalus Zabel of the genus *Malus*. Geographically, none of these hosts are native to North America; all are confined to Eurasia.

(d) The phenomenon of genetic inheritance of susceptibility to the aecial phase of *G. Juniperi-virginianae* seems to be common to hosts in both groups. In the Malus collection in the Arnold Arboretum only two species that developed aecia (therefore placed in group A) originated by hybridization. These species are *M. Dawsoniana* (*M. fusca* × *pumila*) and *M. Soulardi* (*M. ioensis* × *pumila*). Of the parents of *M. Dawsoniana, M. fusca* was very resistant but produced both spermogonia and aecia (table III), while *M. pumila* produced spermogonia only (table I). *Malus Dawsoniana* was very resistant but developed aecia as did its more susceptible parent and in an even shorter period of time (table VII). Of the parents of *M. Soulardi, M. ioensis* was moderately susceptible and produced both spermogonia and aecia (table II), while *M. pumila* produced spermogonia only (table I). *Malus Soulardi* proved to be very susceptible and also produced aecia in a shorter time than its more susceptible parent.

Turning now to the parentage of some of the hybrid species listed in group B (those on which spermogonia only were produced), interesting data are recorded in column three of table II. It is noteworthy that when *M. pumila* and *M. Sieboldii* are crossed with the immune species *M. baccata* and *M. spectabilis* respectively, the hybrid offsprings react towards *G. Juniperi-virginianae* as do the susceptible parents. Here, just as in the cases of hybridization cited for group A, susceptibility to infection by *G. Juniperi-virginianae* seems to be a dominant character. Other crosses between species that produced spermogonia only and immune species as, for example, *M. atrosan-*

guinea (*M. Halliana* × *Sieboldii*) and *M. zumi* (*M. baccata mandshurica* × *Sieboldii*) have resulted in hybrids that so far have proved to be immune. All of the data bearing on this phenomenon, however, indicate that susceptibility to *G. Juniperi-virginianae* was probably due to a complex genetic constitution. (See Crane and Lawrence, 1933.)

(f) A footnote to table II states that *M. prunifolia fastigiata* produced a few abortive aecia. Although this variety was inoculated fourteen times on six different dates, only a single inoculation resulted in the production of aecia. In my judgment, however, this variety should be included with group B because the production of aecia could not be experimentally repeated.

TABLE II.

PRESENTING DATA ON THE HOSTS OF G. JUNIPERI-VIRGINIANAE IN THE GENUS MALUS WHICH PRODUCED SPERMOGONIA ONLY

Host	Taxonomic position	Parentage	Time for development of the spermogonia		Geographical distribution
			Appeared	Oozing	
adstringens	Eumalus	baccata x pumila	30*	--	
astracanica	"	pumila x prunifolia	46	--	
prunifolia	"	a species	16-34	46	eastern Asia
prunifolia fastigiata	"	var. of prunifolia	15-44	20-30**	"
prunifolia fructu coccineo	"	var. of prunifolia	18-22	28-33	"
prunifolia rinki	"	var. of prunifolia	22-33	--	"
pumila apetala	"	var. of pumila	15-37	29	Eurasia
pumila pendula	"	var. of pumila	35	--	"
"Elise Rathke" robusta	"	prunifolia x baccata	61	--	"
Sieboldii	Sorbomalus	a species	26-33	--	Japan
Sieboldii arborescens	"	var. of Sieboldii	19-30	--	Japan and Korea
	"	Sieboldii x spectabilis	21-29	--	

*Figures refer to the number of days after inoculating.
**A few aecia appeared in 62 to 68 days.

III. PRELIMINARY INVESTIGATIONS ON THE DURATION OF A PERIOD OF SUSCEPTIBILITY IN APPLE LEAVES.

Fulton (1913), Reed and Crabill (1915) and Giddings and Berg (1915) have reported that leaves of orchard apples are susceptible to infection by *G. Juniperi-virginianae* for only a brief period in their youth. For the purpose of further investigations, five series of inoculations were made with *G. Juniperi-virginianae* on certain species and

TABLE III.

PRELIMINARY DATA ON "PERIOD OF SUSCEPTIBILITY"

Host	Approximate dates of inoculating										
	May 1		May 19		June 11		July 11		Aug. 2		deg. susc.
	spm	aec	spm	aec	spm	aec	spm	aec	spm	aec	
MALUS											
ioensis plena	*	*	*	*	*	*	*	*	*	*	3
coronaria Charlottae	*	*	*	*	*	*	*	*	*	*	3
angustifolia			*	*	*	*	*	*	*	0	3
glaucescens	*	*	*	*	*	*	*	*	0	0	2
glabrata	tags lost		*	*	*	*	*	*	-	-	2
ioensis	*	*	*	*	*	*	*	*	-	-	2
coronaria elongata	*	*	*	*	*	*	*	0	0	0	2
coronaria	*	*	*	*	*	*	*	0	-	-	2
Soulardi	*	*	*	*	*	*	0	0	0	0	2
platycarpa			*	*	*	0	-	-	-	-	2
sylvestris	*	*	*	*	*	0	-	-	-	-	1
fusca	*	*	*	0	*	0	-	-	-	-	1
prolific	*	*	*	0	0	0	-	-	-	-	1
Sieboldii x spectabilis	-	-	*	0	*	0	-	-	-	-	s
Sieboldii arborescens	*	0	*	0	*	0	-	-	-	-	s
prunifolia fastigiata	*	*	*	0	*	0	0	0	-	-	s
Sieboldii			*	0	0	0	-	-	-	-	s
pumila pendula	0	0	*	0	0	0	-	-	-	-	s
pumila apetala		0	*	0	0	0	-	-	-	-	s
prunifolia fructu coccineo	*	0	*	0	0	0	-	-	-	-	s
prunifolia	*	0	*	0	0	0	-	-	-	-	s
robusta	*	0	0	0	0	0	-	-	-	-	s
prunifolia rinki	*	0	0	0	0	0	-	-	-	-	s
astracanica	*	0	0	0	0	0	-	-	-	-	s
adstringens	*	0	0	0	0	0	-	-	-	-	s
Totals *	19	11	21	11	15	9	8	6	3-5	2-4	
0	1	9	4	14	10	16	17	19	22-20	23-21	
Grand totals	* 30		32		24		14		5-7		
	0 10		18		26		36		45-43		
Percentage successful inoculations	75%		64%		48%		28%		10%-14%		

*, successful cultures; 0, negative results; -, not inoculated.

varieties of hosts in the Arnold Arboretum. Inoculations were made in the manner previously described, the inoculum being kept in a refrigerator during the summer.

It may be argued that the viability of the teliospores decreased during this period and thereby may have had influence upon infection of the leaves. This influence was probably slight, however, since the younger leaves of the very susceptible varieties *M. coronaria Charlottae* and *M. ioensis plena,* seemed to be almost as susceptible in August as in May.

The data on these inoculations are presented in full in table III. That a period of susceptibility existed in the early stages of growth of the leaves is demonstrated by the fact that the greater number of successful inoculations resulted early in the growing season. The total number of positive inoculations as compared with the negative inoculations were in the approximate percentages of 75%, 64%, 28% and 10% to 14% for the inoculations made on May 1, May 19, June 11, July 11 and August 2 respectively. The last percentage is given in pair because certain of the plants that proved to be susceptible in July were not inoculated in August.

The duration of the period of susceptibility varied for the different species and varieties of *Malus*. The more resistant ones were susceptible until about June 1; the moderately susceptible species and varieties were susceptible until about July 1; and the most susceptible could be infected throughout the greater part of the growing season.

IV. OBSERVATIONS ON SPECIES OF JUNIPERUS SUSCEPTIBLE TO G. JUNIPERI-VIRGINIANAE

Our knowledge of the *Juniperus* hosts of *G. Juniperi-virginianae* as determined by cultural studies is due solely to the work of Dodge (1918) and Bliss (1933). These investigators successfully cultured *G. Juniperi-virginianae* on *J. virginiana* L. Heald (1909) and Weimer (1917) also inoculated red cedars but with no positive results. Several other workers, however, reported additional hosts as a result of field observations. Stone (1909) reported *J. bermudiana* (*J. barbadensis*). Kauffman (1916) stated that *J. communis* was susceptible. The recognition of these species as hosts, however, is open to question. Reed and Crabill (1915) reported *J. virginiana Schottii, J. virginiana glauca* and *J. virginiana fastigiata* from Virginia. Hahn, Hartley and Pierce (1917) found that specimens of *J. scopulorum* (the western red cedar) introduced into Illinois became infected. Arthur

(1926) and Bliss (1933) also found that introduced plants of *J. scopulorum* were susceptible to *G. Juniperi-virginianae*. Bliss further reported *J. virginiana elegantissima, J. virginiana globosa, J. virginiana Canaertii* and *J. virginiana Hillii* as susceptible in Iowa. He also examined other varieties of *J. virginiana* as well as species and varieties of *J. communis, J. excelsa, J. chinensis* and *J. horizontalis* and several unidentified species but found them to be immune. Further than the foregoing cultures and field observations, no authentic information is available as to the susceptibility of other species and varieties of *Juniperus*.

In order to add to the information just cited, field observations were made on the extensive *Juniperus* collections at the Arnold Arboretum. In 1933 each individual cedar was examined for infection and the species and varieties were recorded in immune and susceptible groups. The immune species and varieties of *Juniperus* are as follows:

Juniperus chinensis L., *J. chinensis globosa* Hornibrook, *J. chinensis japonica* Lav., *J. chinensis mas* Gord., *J. chinensis pendula* Franch., *J. chinensis Pfitzeriana* Spaeth., *J. chinensis plumosa* Hornibrook, *J. chinensis plumosa aurea* Hornibrook, *J. chinensis pyramidalis* Beiss., *J. chinensis Sargenti* Rehd., *J. chinensis Watereri* Hort., *J. communis* L., *J. communis Ashfordii* Hort., *J. communis aurea* Nichols., *J. communis aureo-spica* Rehd., *J. communis compressa* Carr., *J. communis cracovica* Hort., *J. communis depressa* Pursh, *J. communis hibernica* Gord., *J. communis montana* Ait., *J. communis oblongo-pendula* Sudw., *J. communis oblonga* Loud., *J. communis pyramidalis* Hort., *J. communis suecica* Ait., *J. conferta* Parl., *J. formosana* Hayata, *J. horizontalis alpina* Rehd., *J. horizontalis glomerata* Rehd., *J. horizontalis variegata* Hort., *J. procumbens* Sieb., *J. rigida* Sieb. & Zucc., *J. Sabina* L., *J. Sabina cupressifolia* Ait., *J. Sabina pyramidalis* Hort., *J. Sabina tamariscifolia* Ait., *J. Sabina variegata* Carr., *J. scopulorum horizontalis* D. Hill, *J. squamata* Buch.-Ham., *J. squamata Fargesii* Rehd. & Wils., *J. squamata Meyeri* Rehd., *J. squamata Wilsonii* Rehd., *J. virginiana aurea, J. virginiana Burkii, J. virginiana Canaertii* Sénécl., *J. virginiana Kosteri* Beiss., *J. virginiana pyramidalis glauca, J. virginiana plumosa* Rehd., *J. virginiana tripartita* R. Smith and *J. virginiana venusta* Rehd.

In table IV are given those species and varieties of *Juniperus* susceptible to *G. Juniperi-virginianae*. Those hosts that were not observed as susceptible in the Arnold Arboretum collections, but were reported by other workers, are marked with a star.

TABLE IV.

A COMPLETE LIST OF THE KNOWN JUNIPERUS HOSTS OF GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE SCHW.

Juniperus
*bermudiana L.
*communis L.
horizontalis Moench.
Douglasii Rehd.
plumosa Rehd.
scopulorum Sarg.
viridifolia
var.
virginiana L.
*Canaertii Sénécl.
Chamberlaynii Carr.
cinerascens Hort.

Juniperus
virginiana L.
elegantissima Hochst.
fastigiata Hort.
filifera D. Hill.
glauca Carr.
globosa Beiss.
*Hillii Hort.
pendula Carr.
polymorpha Hort.
pyramidalis Carr.
reptans Beiss.
Schottii Gord.

*These hosts were reported by other workers, but were not observed as susceptible in the Arnold Arboretum.

In the genus *Gymnosporangium* it is usual to find that all of the telial hosts of any one species are confined to but one section of the genus *Juniperus*. *Gymnosporangium Juniperi-virginianae* follows this general rule, for its hosts (with the exception of the doubtful host *J. communis*) belong exclusively to the section Sabina.

Geographically these hosts, with the exception of *J. communis*, occur only in North America. *Juniperus bermudiana* is found along the Gulf coast of the United States and in Bermuda. *Juniperus virginiana* occurs in eastern North America over the entire geographical range of the pomaceous hosts in the section Chloromeles. *Juniperus horizontalis* occurs over this same territory and even farther north into Canada. *Juniperus scopulorum* is found in western North America west of the great plains region. The geographical distribution of the Juniperus hosts is shown as horizontal lines on the map in fig. 1 (page 188).

V. SYMPTOMATOLOGY AND RANGE OF THE DISEASES CAUSED BY G. JUNIPERI-VIRGINIANAE

1. Morphological Symptomatology—(a) on Pomaceous Hosts.

Both Schweinitz (1832) and Farlow (1880) gave brief descriptions of the gross morphological symptomatology of the disease produced on the leaves of apples. These descriptions seem to have been primarily to aid in the identification of the fungus. Seymour (1886) emphasized the aecial phase of this rust as disease-producing. He described numerous instances in which orchards in the vicinity of red

cedars were severely injured by the rust. Stewart and Carver (1886) also reported serious damage to apple trees and noted further that certain varieties were more susceptible to the rust than others. Thaxter (1887) observed that not only the leaves but also the fruits and twigs were attacked. Pammel (1905) reported a sudden outbreak of the disease in Iowa in 1905. Heald (1909) drew attention to differences in the susceptibility of certain varieties of apple trees and reported that indirect losses as well as direct losses were often very great. Heald also gave a careful description of the symptoms of disease. He found that the rust first showed as yellow spots on the upper surface of the leaves in from seven to ten days after infection and that the spermogonia appeared in a few weeks. With further development the leaf tissues beneath these spots swelled to a cushion one-fourth to one-half inch in diameter and it was on these that the aecia were produced. Heald noted further that on the resistant varieties of apple "the rust spots remain minute and undeveloped for the entire season," also "in certain cases—the leaf tissue is killed at the point of infection."

In the decade from 1910 to 1920, the cedar-apple rust disease was unusually severe on apples in eastern North America. This furnished a great stimulus for further studies as well as ample opportunity for observations on many details of the disease. Several important findings resulted. Fulton (1913) observed that the leaves of many varieties of apples were not susceptible immediately after breaking bud, but in a few days thereafter they entered a brief period of susceptibility; after that they became immune. Reed and Crabill (1915) substantiated Fulton's observations. They also advanced theories of much interest on the nature of the resistance of apple leaves to *G. Juniperi-virginianae*. They expressed the opinion that two types of resistance were present, namely, (a) "some mechanical, morphological or chemical preventative of infection exists in the epidermis while the palisade and mesophyll tissues are a congenial medium for the growth of the parasite." (b) "In the second type infection takes place as in the susceptible varieties, the lesions develop until they are about 1 mm. in diameter and then they cease to enlarge. No mature spermogonia or aecia are produced."

Giddings and Berg (1915) showed that the leaves of certain varieties of apples were immune for the first ten days after unfolding. They add, however, that mature leaves may become infected following insect injuries, needle punctures or on the torn edges of the leaves. They believe that resistance is "due evidently to a thickening and

hardening of the epidermal cells, as well as to other chemical changes in the interior of the leaf." Giddings (1918), after a very extended study, determined that leaves of "York Imperial," variety of orchard apple, were susceptible to rust infection for fifteen to twenty-five days after they unroll from the bud.

Many workers have reported on the relative susceptibility to orchard apples to the cedar-apple rust disease. Among these are Chester (1896), Lloyd and Ridgway (1911), Jones and Bartholomew (1912), Reed and Crabill (1915), Giddings and Berg (1915), Gardner (1925), Thomas and Mills (1929), Miller (1931), Bliss (1933) and many others. These reports, together with those received in letters to the writer from thirty-six state experiment stations, have been compiled as a part of this study and will be presented as a separate publication.

Only one publication, namely, that of Reed and Crabill (1915), deals with the histological symptomatology of cedar-apple rust. Among their most important findings are (a) "the mycelium of the rust fungus in the apple leaf, is much like that in the cedar apple. It is about the same diameter and ramifies through the leaf in the vicinity of the infection, occupying the intercellular spaces and sending haustoria into the cells of its hosts." (b) "The first symptoms of disease appear about one month after infection as small yellow spots on the dorsal surface of the apple foliage. Spermogonia are formed immediately under the upper epidermis of the leaf." (c) "The hypertrophy of the apple leaf is due almost entirely to an excessive enlargement and multiplication of the spongy parenchyma cells. The thickened spots on the leaves begin to be distinct about the first of July and by the middle of that month aecidia which are borne on the ventral surface begin to break open." (d) "The tissues of the apple fruit are also much hypertrophied. Deep down in this layer the aecidia begin to form and after reaching maturity the aecidium is finally pushed bodily out of the fruit leaving a hole in the skin."

From the accounts found in textbooks and in original papers just reviewed it is apparent that the symptomatology of cedar-apple rust on pomaceous hosts is almost exclusively based on phenomena as observed on orchard apples. To these accounts I have little to add. My own studies, however, embracing observations on a wide range of species of *Malus*, have brought additional phenomena to light; hence for the purpose of calling attention to certain variations, comparisons and correlations an extended description of the symptomatology of this disease is presented with all susceptible species of *Malus* studied by me kept in mind.

In the following account of my own work the more nearly average symptomatology as found on the native species and varieties of *Malus* will be described and variations from this will be dealt with in turn.

The first manifestations of the disease were found from six to ten days after inoculation as pale yellow discolorations on the upper surface (rarely on the lower surface) of the young leaves. These discolored spots increased in size and in intensity of color until about the tenth to the fifteenth day after inoculation when the spots, from five to ten mm. in diameter, became dotted with a few to several minute, deep-yellow points. These were the immature spermogonia forming beneath the epidermis. In from three to five more days the spermogonia ruptured the epidermis, and a clear-yellow, sweetish fluid exuded from their tiny ostioles. Throughout the development of the spermogonia the infection spots on the upper surface of the leaf continued to increase in size to a maximum diameter of about fifteen mm. at which time they were usually bordered by a deep-yellow to bright-red peripheral zone. After the spermogonia ceased oozing they usually turned black and appeared not unlike pycnidia of certain ascomycetous fungi.

Following the maturation of the spermogonia, further symptoms of the disease and signs of the fungus were found on the under-surface of the leaf. Immediately beneath the spermogonia the cells of the infected tissue began to increase in size and number. This was manifested as an irregular, more or less hemispherical swelling from two to ten mm. in diameter. This swelling was first observed from twenty-five to thirty-five days after the inoculations were made. The first evidence of the aecia was observed from sixty to seventy days after inoculating as minute swelling of the epidermis on the swollen cushions. Within the next two to four days, the aecia pierced the epidermis and appeared as grayish acuminate cylinders about one mm. in diameter. The peridium of the aecium split along the sides and curved outward, releasing the enclosed brownish aeciospores.

The development of the disease and of the fungus seemed to be correlated directly with the degree and duration of susceptibility of the pomaceous hosts. In the most resistant hosts including the foreign species and varieties of *Malus* and about twenty-seven per cent of the varieties of orchard apples, the lesions developed only to the formation of small, pale-yellowish discolorations, and the fungus to the production of one or but a few abortive spermogonia. In certain of the hosts a few aecia were also produced. These symptoms and signs appeared from a week to a month later than the normal ones. In the fourth column of table II is recorded the time required for the production of

spermogonia on the exotic species and varieties of *Malus* susceptible to *G. Juniperi-virginianae*. In table VII is given the time in days required for the production of aecia on the most resistant as well as other species of *Malus*. In the more susceptible hosts, including most of our native species and about twenty-one percent (as compiled from the literature) of the varieties of orchard apples, the disease developed more rapidly and to a greater extent than average. The symptoms appeared a few days earlier, and even in a shorter time developed to a greater extent and produced more fruiting structures than the more resistant hosts.

To demonstrate these variations mathematically, a very susceptible, a moderately susceptible and a very resistant host were chosen and several pertinent measurements were made of the diseased tissues and of the fungus. These data are presented in table V.

TABLE V.

PRESENTING DATA ON CERTAIN POMACEOUS HOSTS IN THREE CATEGORIES OF SUSCEPTIBILITY

Host	Plate 93	Degree of susceptibility	No. of cushions per Leaf	No. of Aecia per Cushion	No. of Aecia per Leaf	Av. size of cushions in mm.	Size of Aeciospores
Malus	fig.						
coronaria Charlottae	1	3	5.2	76.0	375.2	55.9 x 45.3	26.23μ x 22.37μ
platycarpa	2	2	9.1	11.7	106.5	33.8 x 26.0	24.88μ x 22.08μ
fusca	3	1	1.7	3.6	6.1	usually lacking	24.42μ x 21.25μ

An analysis of these data shows that the amount of infection, the number of fructifications and the size of the aeciospores vary directly with the degree of susceptibility of the hosts.

In plate 93 are shown photographs on diseased leaves of each of the foregoing and other hosts. In table II are presented data derived from inoculations made periodically on species and varieties of *Malus* of all degrees of susceptibility. From this table it is seen that the degree of susceptibility of the host is directly correlated with its period of susceptibility. The most susceptible apples became infected throughout the greater part of the growing season, while the less susceptible ones could be infected over only decreasing periods of time.

With the increase in age, the leaves of all the hosts became more and more resistant. When inoculations were made in mid-summer, many of the very resistant hosts were then found to be immune, while the more susceptible ones reacted to infection as did the less susceptible hosts earlier in the season. Toward the end of the growing season, many of the infections on the leaves of the more resistant hosts died. On September 6, 1932, and about the same date in 1933, many of these dead areas were found on the resistant species *M. fusca, M. sylvestris* and *M. Dawsoniana;* but practically none were found on the susceptible hosts *M. ioensis plena, M. coronaria Charlottae* and *M. angustifolia.* These phenomena indicate that resistance is due, in part at least, to histological changes in the host protoplasm. It should be added, however, that I could detect no significant morphological differences in the leaves of any of the species at any time of the year.

In table VI are listed the species and varieties of apples whose fruits, twigs and buds are attacked. It will be seen that fruit and twig attack are quite common among the native species and varieties of *Malus* as well as among the orchard apples. The forced growth of infected buds is, so far as known to me, found only on hosts of the genus *Malus* other than orchard apples.

While the symptomatology on the apple leaves has been correlated with certain features, that on the fruits, twigs and buds has not, in my experience, been found to be so correlated.

The symptomatology of the disease in the fruits, twigs and forced grown buds now calls for description. The yellow discoloration and spermogonia appeared on the surfaces of the young fruits and pedicels at about the same time as on the leaves of the apples. The infected fruits increased in size and were variously distorted. The hypertrophy, however, soon reached a maximum, and subsequent growth of diseased fruits was greatly lessened. About the time that aecia appeared on the leaf they also matured on the infected fruits. On the fruits, however, they broke through the epidermis among the spermogonia. The lesions were found on any part of the fruit but seemed to be more abundant on the calyx end.

The development of the spermogonia and aecia and the production of the hypertrophied areas were essentially the same on the twigs of the current season as on the fruits. It frequently happened, however, that when a twig was attacked by this rust the infection spread along the twig and involved a lateral or a terminal bud of the coming season. Inoculation experiments showed also that in certain of the most susceptible native apples the unfolding buds of the current season were also

TABLE VI.

SPECIES AND VARIETIES OF APPLE SUBJECT TO FRUIT ATTACK, TWIG ATTACK AND THE FORCED GROWTH OF BUDS CAUSED BY GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE SCHW.

Fruit Attack	Twig Attack	Forced Growth of Buds
MALUS	MALUS	MALUS
angustifolia	angustifolia	angustifolia
bracteata	bracteata	bracteata
coronaria	coronaria	coronaria
Dawsoniana	glabrata	glabrata
glabrata	glaucescens	ioensis
glaucescens	ioensis	ioensis plena
ioensis	ioensis plena	Soulardi
ioensis plena	lancifolia	
lancifolia	Soulardi	
Soulardi		
Orchard Varieties	Orchard Varieties	
Ben Davis	Ada Red	
Delicious	*Arkansas	
Early Harvest	Bayfield	
Esopus	*Benoni	
Gideon	Duchess	
Grimes	Golden Delicious	
Jonathan	*Jonathan	
Oldenburg	*Malinda	
Red Delicious	Missouri Pippin	
Red June	*Okabena	
Rome	*Peerless	
Sutton	*Red Astrachan	
Twenty Ounce	Red June	
Wealthy	Rome	
Winesap	Salome	
Winter Banana	Smith Cider	
Yellow Bellflower	*Stayman	
Yellow Transparent	*Twenty Ounce	
York	*Wagener	
	Wealthy	
	*Whitney	
	*Winter Banana	
	Yellow Bellflower	

*Bliss (1933) reports that only spermogonia were produced on these varieties.

directly infected. When buds became infected they acted in a most peculiar manner, which, so far as I am able to learn, has not been described before. Bliss (1933), however, observed infected buds on *M. ioensis plena* in Iowa. The infected buds swelled greatly, their scales opened and the young parts began to grow. With later development the infected twig increased greatly in diameter but elongated very slightly, the leaves expanded to an irregular shape and were considerably, yet uniformly, thickened; they were pale green in color and very tenacious of their tomentum. The first spermogonia to appear were at the base of the pedicels. In a short time others developed progressively along the petioles, then on the bases of the leaves; finally, they extended over the entire blade. This wave of development and maturity of the spermogonia was followed by a similar wave of development and maturity of the aecia. At certain times one may find all stages of development of both fructifications on the same leaf. The phenomenon of the forced growth of buds seems to be confined to the most susceptible native apples. Of these, *M. ioensis plena* and *M. Soulardi* were particularly susceptible. A count of such infection on a tree of *M. ioensis plena* showed that about fifteen percent of the buds were attacked. A large nursery was visited in which small specimens of *M. ioensis plena* were planted near infected red cedars. Every twig of the apples was found to be attacked and whole rows of the plants were killed outright. I know of no report of the forced growth of buds in orchard varieties of apples. In plate 95 are shown several photographs of forced growth of buds in various stages of development.

These studies on apple other than orchard apples emphasize three important points:

(a) Hosts on which the lesions are of larger than average size are more susceptible than those on which they are characteristically smaller.

(b) Hosts on which the development of the rust is more rapid are more susceptible than those on which it is slower.

(c) The duration of susceptibility is longer on the more susceptible hosts; indeed, duration of susceptibility is to some degree an index of relative susceptibility.

These phenomena likewise exist in orchard apples. It follows then that the more resistant orchard apples require protection during the early part only of the growing season, while the more susceptible varieties should be protected throughout the entire period of spore discharge from the red cedars.

1. Morphological Symptomatology—(b) on Red Cedars.

The symptoms and signs of cedar-apple rust on red cedars were carefully described by Farlow (1880). He was of the opinion that the galls caused by *G. Juniperi-virginianae* on red cedars were modified leaves. The galls "begin to appear about the end of August and often reach a considerable size before winter." He observed great differences in the size of the galls, "some quite small, so that not more than two or three columns can find attachment, but generally the knots grow from half an inch to an inch and a half in diameter before the gelatinous masses break through the surfaces." He continued—"The latter arise a short distance below the surface, and the outer portion of the knot consisting of several layers of cork cells is raised in flattened papillae. By growth of the gelatinous masses, the center of each papilla is ruptured and the columns arise vertically. In by far the majority of cases, the knots gradually dry and drop off after having borne one crop of spores. In rare instances, however, a new knot may grow from one side of the old knot and bear a second crop of spores." Both Farlow and Schweinitz were of the opinion that the galls were annual. Heald (1909), however, showed that they were biennial, requiring approximately twenty-three months between the time of inoculation and the production of spores. Dodge (1918) confirmed Heald's findings in this respect. Reed and Crabill (1915) reported that in rare cases galls have been found to produce a second crop of spores. Bliss (1933), however, reported that he observed that 20% of the smaller galls produce a second crop of telia and added that some galls produced even a third crop.

The problem of immunity and resistance of red cedars to attack by *G. Juniperi-virginianae* has been a matter of considerable speculation. Giddings and Berg (1918) gave an account of certain observations made by Professor H. H. Whetzel with regard to this phenomenon on red cedars. "I observed that certain cedar trees were badly infected, being loaded with galls, large and small, on all their twigs and branches. A few years later, to my astonishment they were practically free from galls, while others nearby that had borne no galls before were now badly covered with them. What the explanation of this phenomenon is I do not know." Reed and Crabill (1915) stated, "The great difference in susceptibility of cedar trees seems to be individual. Susceptibility also seems to be cumulative. A tree once infected becomes increasingly susceptible from year to year as the increasing number of cedar apples indicate." On the other hand Giddings and Berg (1915) wrote "In sections where the rust is destructive, it is quite common

to see cedar trees with few or no galls, while other trees within a few feet are actually loaded down with them. Close observation of these 'immune' cedar trees has led up to believe that such immunity as they possess is often a direct result of previous heavy infections." They also state "if the tree has been severely diseased with this rust for two or more successive seasons, its growth is greatly inhibited and the opportunity for infection would be proportionately reduced."

The histological structure of the cedar-apple galls caused by *G. Juniperi-virginianae* has attracted much attention. Farlow (1880), Sanford (1888), Coons (1912), Reed and Crabill (1915), Giddings and Berg (1915) and Weimer (1917) are of the opinion that cedar-apple galls are modified leaves. Wörnle (1894) and Heald (1909) believe that the galls originated in the stem of cedar trees; while Stewart (1915) concludes that the galls are modified axillary buds.

To the symptomatology of the disease as recorded in the literature, referred to above, I now add certain field observations of my own.

On red cedars the symptoms and signs are restricted to the needles and adjacent twig tissues of the host plant. The earliest morphological symptoms of disease were observed about the middle of June in Massachusetts. These appeared as slightly swollen green lesions on the adaxial surfaces of the leaves. On the scale-like leaves these swellings were very difficult to detect, and as they increased in size it appeared as if the galls were primarily twig infections. On the subulate leaves, however, it was evident that the lesions or galls were primarily foliar in origin. During subsequent growth the galls increased rapidly in size always retaining a more or less globose form, though they were often considerably infolded or convoluted. The color of the galls gradually changed from a light dull-green of the early summer to a dull, chocolate brown of the fall and winter. The features of a change of color from greenish to brown and a constantly dull surface served to distinguish the gall caused by *G. Juniperi-virginianae* from another gall form in this region, namely, the gall caused by *G. globosum* Farl. The latter retains a deep-brown varnished surface during the entire first season of growth.

Towards the end of the growing season, the galls caused by *G. Juniperi-virginianae* formed characteristic, shallow, circular depressions on their surfaces and in the center of each depression a low papilla developed. These phenomena were typical of the larger galls in winter condition. Many of the smaller ones, however, did not form these depressions until the early spring and some seemed never to have formed them at all. During early March the papillae increased in

diameter and height and became very conspicuous. In the first warm rains of late March and early April the swollen papillae were ruptured, usually by a single slit, and the underlying brownish sorus was exposed to view. During subsequent rains the telia progressively protruded and expanded as yellow gelatinous masses to a maximum of three to five mm. in diameter by about thirty to fifty mm. in length. Upon drying, the telia contracted to distorted, slender, brownish tendrils.

The number of galls on cedar trees varied tremendously. Certain trees were apparently immune while others near at hand had but a few galls or were literally loaded with them. A branch twelve inches in length from a heavily infected tree was found to bear two hundred and fifty galls of various sizes. The size of the galls and the number of telia they produced also varied widely. The smallest galls were but two to three mm. in diameter and produced one or two telia only. Average-sized galls measured two to three cm. in diameter and produced from seventy to one hundred telia. A large-sized gall measured five and one-half cm. in diameter and produced three hundred and forty-seven telia.

Gelatinization and drying of the telia usually occurred six to eight times during a season, but by the middle of June most of the telia had dropped from the galls, after which both the galls and the fungus died. It frequently happened, however, that the galls remained on the tree in a more or less blackened and mummified condition for several months; occasionally the dead telia adhered also. In rare instances certain of the smaller galls resumed growth for a second season. In plates 96 and 97 are shown galls and telia of *G. Juniperi-virginianae* in various stages of development.

2. Histological Symptomatology—(a) on Pomaceous Hosts.

The histological symptomatology on the pomaceous hosts was very similar in all of the infected tissues. In the following account the more nearly average symptoms and signs will be described and attention will be called to any irregularities that were observed.

In the leaves of the apples the earliest observed sign of infection was the presence of hyphae among the palisade and mesophyll cells. Shortly after invasion of the tissues by the mycelium, protoplasmic symptoms of disease were observed as globules of deep-staining material in the infected cells. From six to ten days after inoculation densely intertwined masses of hyphae, the spermogonial primordia, were observed in various stages of development between the palisade layer and the upper epidermis. These primordia developed to mature sper-

mogonia by the fifteenth to twentieth day. During this interval the mesophyll cells increased slightly in size but seldom sufficiently to fill all of the intercellular spaces. The mycelium also increased in amount and occupied a greater area, as was evidenced by microscopic examination and the increase in size of the yellow discolorations on the surface of the leaves. During maturation of the spermogonia hyphae were observed to have formed haustoria in many of the parenchymatous cells. The haustoria were variable in size and shape, as shown in the camera lucida drawings in plate 94 fig. 7. Usually but a single haustorium was found in a cell; occasionally, however, two or three were observed.

Following the maturity of the spermogonia the mesophyll cells increased greatly in size and number and completely obliterated the intercellular spaces. The hypertrophied cells elongated at right angles to the surface of the leaf and forced the lower epidermis outward. From forty to sixty days after inoculations were made, compact masses of mycelium were formed just beneath the palisade layer in the hypertrophied mesophyll tissue. These masses of hyphae, the aecial primordia, elongated towards the lower epidermis. The central hyphal cells of the primordium gradually disintegrated and within this space the aecium was formed. From sixty to seventy days after inoculating, the aecia penetrated the lower epidermis of the leaf. One to three days later the peridial cells of the aecium separated along their sides, turned outward in characteristic fashion and released the aeciospores. A cross-section of a leaf at the border of an infected area is shown in plate 94, fig. 1. It is evident from this photomicrograph that the swelling of the leaf was due entirely to the elongation of the parenchymatous cells of the mesophyll tissue. In many instances it is clear that the mesophyll cells divided one to three times. Very little morphological change was observed in the palisade cells or in the upper or lower epidermis.

In the fruits the mycelium developed somewhat differently than in the leaves. Instead of being localized as was characteristic of leaf infections, the mycelium sometimes invaded the whole fruit. The infected parenchymatous tissue beneath the epidermis of the fruits responded to attack as did the mesophyll tissue of the leaf. In the smaller fruits the histological changes were observable almost to the core, but in the larger fruits histological changes extended over a portion only of the tissues. The spermogonia developed immediately under the epidermis of the fruit and appeared in all respects similar to those on the leaves. The aecial primordia were located about three

mm. below the epidermis, and upon reaching maturity penetrated the surface of the fruits among the spermogonia. In the twigs the fungus and the disease developed essentially as in the fruits.

In certain of the more susceptible species of *Malus*, buds of the current and the following season occasionally became infected and the embryonic tissues were forced. Within these tissues the symptomatology was somewhat different than in localized infections. The mycelium invaded all but the vascular tissues of the leaves, petioles and stem. Fructifications developed and matured progressively from the bases of the infected organs to their tips. Thus in a leaf while spermogonia were forming on the blade others were maturing nearer its base; these in turn were followed by developing aecia on the base of the leaf and by mature aecia on the petioles. The infected organs were greatly hypertrophied and showed histological changes similar to those already described. In the leaves, however, the mesophyll cells were much less hypertrophied than those in the localized infections; and the intercellular spaces were large and numerous. An unusual character of leaves of forced buds was that the tomentum, when present, remained constantly attached to the epidermal cells. The leaves on these buds usually adhered throughout the winter in a blackened condition. The forced buds and the portion of the twig or branch beyond them were killed, in all cases observed, during the winter. I have never observed the aecial phase of *G. Juniperi-virginianae* to overwinter.

In plate 95 are shown several photographs of forced buds in various stages of development.

2. Histological Symptomatology—(b) on Red Cedars.

The earliest symptoms of disease seen consisted of but a few enlarged parenchymatous cells in the leaves only of red cedars. The infected cells gradually increased in size and in number and produced globose swellings or galls on the leaves. During this development the vascular system of the leaves was also hypertrophied and ramifications were present throughout the galls. At maturity the galls varied in size from two to forty mm. in diameter and were covered with a thick epidermis of cork cells. In concave depressions just beneath the epidermis, the cells of the galls seemed to be retarded in their development. Within these areas the mycelium formed stromata of several compact layers of hyphae and from these the telial fructifications were developed.

The protoplasmic contents of the cells of the galls contained many small, deep-staining globules similar in many respects to those in the infected cells of the apple leaves. Certain of the cells of the galls,

however, seemed to be completely filled with a fine, granular, deep-staining substance.

3. Range of the Diseases Caused by G. Juniperi-virginianae.

At the present time, the diseases caused by *G. Juniperi-virginianae* have been reported from all but Arizona, California, Idaho, Nevada, Oregon, Utah and Washington in the United States and from Ontario only in Canada. In figure 1 is shown the distribution of the disease as dots on an outline map of North America. While the present range of the cedar-apple rust disease is delimited within the coinciding ranges of the pomaceous and Juniperus hosts in eastern North America, it must be borne in mind that host relationships are favorable for the organism over the greater part of western as well as eastern North America. The alternate hosts in eastern and western North America are separated from each other geographically by the great plains region of central North America.

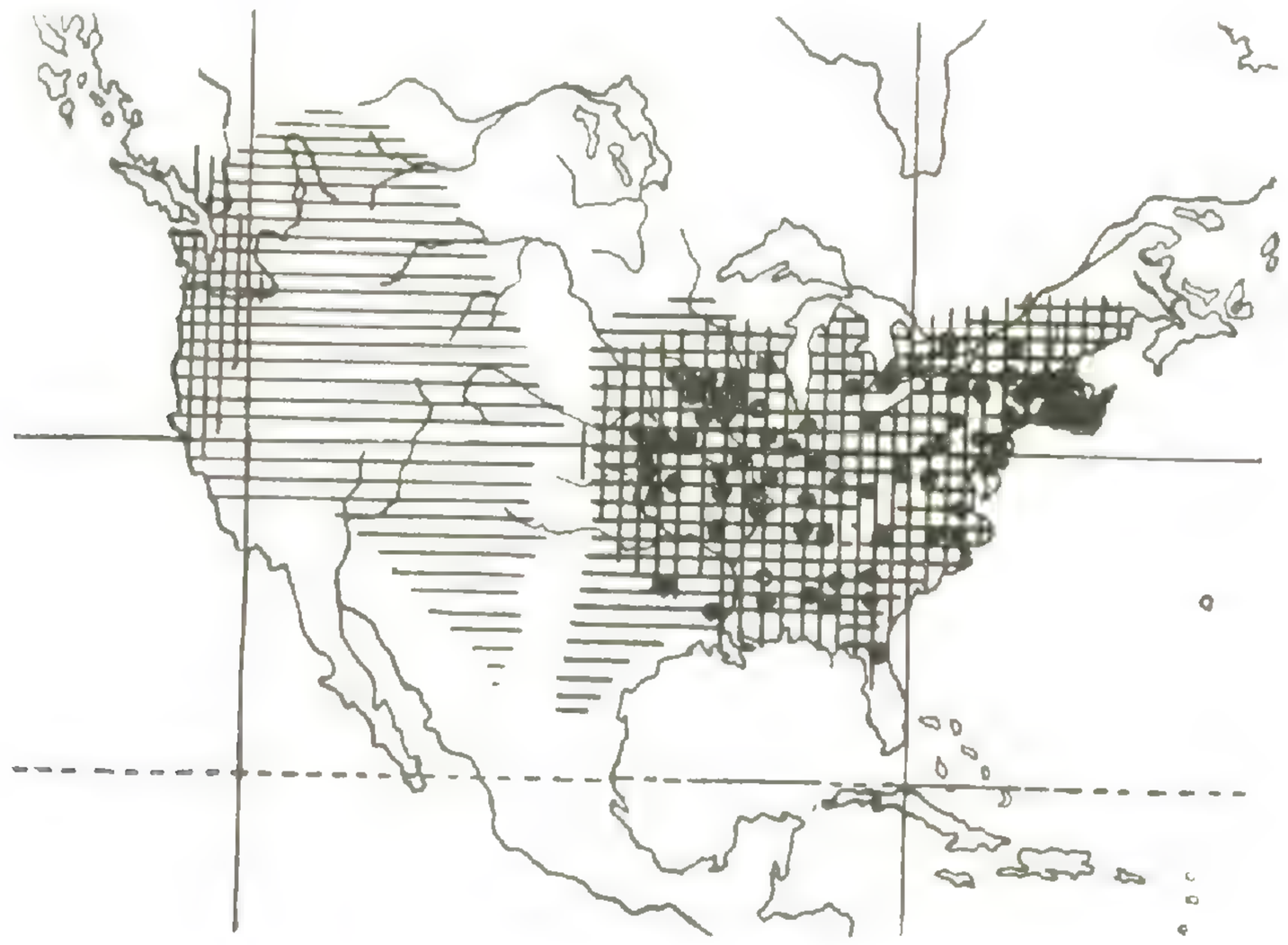

Figure 1. Geographical distribution of

(a) the pomaceous hosts of *G. Juniperi-virginianae* is shown as vertical lines.

(b) the *Juniperus* hosts (exclusive of the doubtful *J. communis*) is shown as horizontal lines.

(c) *G. Juniperi-virginianae* is shown as dots.

It will be noted that the fungus is abundant over the coinciding ranges of the apples and eastern red cedars in eastern North America, but has not been reported on apples or the western red cedars in western North America. The great plains region separates these two groups of alternate host plants.

VI. LIFE HISTORY STUDIES OF G. JUNIPERI-VIRGINIANAE

Schweinitz (1822) described *G. Juniperi-virginianae* from the telial phase found on red cedars in North Carolina. This was the first species of the genus *Gymnosporangium* to be described from North America. Link (1825) described the same species as *G. macropus*, a name that was given preference over the former by many of the earlier writers. According to the 1910 rules of botanical nomenclature, however, priority is given to the name *G. Juniperi-virginianae*. Schweinitz (1832) described the aecial phase of this rust from material on *Malus coronaria* as *Caeoma* (*Aecidium*) *pyratum*.

In 1875 Professor W. G. Farlow working at the Bussey Institution of Harvard University attempted for the first time (as far as can be ascertained) in North America to culture a rust fungus. Professor Farlow sowed basidiospores of *G. Juniperi-virginianae* on leaves of two small plants of *Amelanchier canadensis*, but without positive results. It was not until the cultural studies of Halsted (1886) and Thaxter (1887) that *A. pyratum* and *G. Juniperi-virginianae* were shown to be genetically connected.

From his extensive cultural studies of several species, Thaxter summarized the life history of *Gymnosporangia* in general. "The *Gymnosporangia* on cedars produce spores (teleutospores), and these in turn produce sporidia which, falling on various *Pomeae*, result in the formation of *Roestelia*, producing aecidial spores, which serve to reinfect the cedars with *Gymnosporangia*." Thaxter further stated that the aeciospores of *G. Juniperi-virginianae* were about 25 μ in diameter and that the peridial cells were "about 22 μ x 80 μ and are marked by striae running obliquely and anastomosing obscurely, the outline of the cell being broken by coarse ridges. The cells when isolated tend to become curved outward—a fact to which is due the outward curling of the peridial lacerations." From his cultures on *M. pumila* (*M. Malus*) Thaxter found that the spermogonia appeared on spots on the upper surface of the leaves in about twenty-two days after inoculating and that aecia reached maturity on the lower surface in about seventy-one days.

Pammel (1905) stated that "The first appearance of the fungus upon wild crab is an orange patch varying from one-sixteenth to one-quarter of an inch across or occasionally somewhat larger." and that "the spermogonia make their appearance in from ten to eighteen days after inoculating."

Heald (1909) reported that the "rust shows first on the upper surface of the leaves as pale yellow spots about the size of a pinhead.

These spots begin to show a week or ten days after the 'cedar apples' have been in the gelatinous condition." Heald also noted an increase in the size and depth of color of the infection spots with age. "In a few weeks after the appearance of the spots, minute pustules appear in the center of each, and these later show as small black specks. These black specks represent the openings of the pycnia—which are flask shaped structures sunken in the tissues of the host." Heald described the aecia as occurring on cushions or blisters one-quarter to one-half inch in diameter immediately beneath the spermogonia.

Kern (1912) gave measurements of the aeciospores of *G. Juniperi-virginianae* as 16 to 24 μ x 21 to 31 μ and the peridial cells as 10 to 16 μ x 65 to 100 μ.

Reed and Crabill (1915) reported that the spermogonia reached maturity in about one month after infection. "The spermogonia are formed immediately beneath the epidermis of the leaf. A dense mass of short-celled mycelium collects at this point and grows until a size of about 130 x 120 μ is obtained. As development goes on the mycelium is seen to arrange itself in strands approaching a point at the apex which is to be later the ostiole. No distinct wall is present in the spermogonium, the strands which give rise to the spermatia being continuous with the strands which ramify between the host cells. At maturity the spermogonium ruptures the overlying epidermis, the fungus strands are somewhat protruded, and by abstriction the spermatia are cut off from these strands. The spermatia are thus continuously produced as are the conidia of mildews, until all of the mycelium of the spermogonium is used up and only a hollow space remains under the epidermis. The spermatia are ovate to club-shaped and measure 2 x 6 μ. Repeated attempts to germinate these spores have failed." Reed and Crabill also state that the mycelium is very similar to that in the cedar gall, but that it is uninucleate in the leaf. They found that the haustoria are "filamentous, much contorted and exist in the palisade cells and the spongy parenchymatous cells." These authors also reported that "the aecidia are initiated by the collection of a globular mass of mycelium in the hypertrophied spongy parenchyma immediately beneath the palisade layer. This mass gradually enlarges and elongates toward the lower epidermis as the aecidiospore chains lengthen. Meanwhile the outermost aecidiospores are differentiated to form peridial cells." They found also that the spermogonia and aecia in the fruit were identical with those in the leaf.

Liu (1933) reported that the mycelium in the apple leaf became very indistinct during formation of the fructifications, but that it was clearly visible at other times.

Many workers have contributed information on the germination of the aeciospores of *G. Juniperi-virginianae,* but to date this phenomenon is little understood. Heald (1909) found that the aeciospores germinated best in July and August in Nebraska. Reed and Crabill (1915) found it impossible to obtain germination of the aeciospores. Weimer (1917) obtained 25% to 75% germination on two tests, but 0% to 1% germination on many other trials. Thomas and Mills (1929) stored the aeciospores for eight weeks at 3°C. and obtained 80.5% germination. Miller (1932) periodically tested the germinability of overwintered aeciospores and found an increase in germination up to March 1929 and up to January 1930. The maximum germinations were 84% and 46% respectively. Bliss (1933) found that refrigeration greatly increased germinability; "the spores showed 16.8% germination when collected (July 28), but after the lot was divided the percentage germination in the refrigerated portion increased rapidly for at least twenty-two days, while that held at room temperature for the same interval dropped to zero." "These results suggest that aecidiospores of *G. Juniperi-virginianae* may infect red cedars when liberated from the aecidium but that refrigeration will increase and prolong their germinability."

No studies, however, have yet been made, so far as can be ascertained, regarding the infection of leaves of red cedars by aeciospores of *G. Juniperi-virginianae.* We are also at a loss to know when or under what conditions infection occurs. However, the telial or diploid phase of this organism in red cedars has received much attention and many interesting phenomena have been brought to light.

Farlow (1880) stated that the telial "mycelium of *G. Juniperi-virginianae* (*G. macropus*) is abundant and easily seen. It is found principally in the leaves and there are haustoria that enter the parenchymatous cells.—In some cases, the gelatinous columns are produced when the knots are quite small." The former "arise a short distance below the surface" and "by growth of the gelatinous masses the columns arise vertically." Lloyd and Ridgway (1911) found that during each of several rains the gelatinous masses elongated by further development of the sori in the gall. Reed and Crabill (1915) stated that the mycelium is "found occupying a portion of the intercellular spaces between the parenchymatous cells. The mycelial threads ramify throughout the cedar apple and grow for the most part closely appressed to the walls of the host cells." Haustoria were found only in the parenchymatous cells; they were "uniformly club shaped."—"The production and development of haustoria is very slow during the

summer, autumn and early winter, and in March just prior to the production of teleutospores haustoria were in great abundance." These authors also stated that "the first step in development of teleutospores is the formation of a compact mass of much-branched short-celled mycelium just beneath the cortex. This condition first becomes apparent about sixteen months after infection of the cedar leaf, that is, in the second December of its development. A layer of erect rectangular cells arise from this mycelial mass just beneath and perpendicular to the cortex. These cells elongate and their tips take on gradually the character of incipient teleutospores.—Soon after the teleutospore becomes recognizable as such the two nuclei in each cell fuse, the walls become much thickened, the stalk cell rapidly elongates into a pedicel and the spore is thus carried upward."

Dodge (1918) found that hyphae were in much greater abundance in the regions just beneath the depressions. "The upper cells grow against the cork layers and become somewhat flattened but they are usually slightly longer than the cells beneath.—The buffer cells finally become two or three times their original length and contain a thin watery substance that is lightly colored with orange G. Their walls become thinner and thinner and finally disappear altogether. After the buffer cells have lost their contents the cells below bud out, their nuclei move up to the base of the bud and divide.—A septum is formed at once. The young binucleate teleutospore bud grows comparatively slowly so that these stages are fairly abundant at the center of the young sorus. Buds may push out of the sides of the basal cell and later three or four buds may be formed from one cell."

Several workers have observed different types of germination of the teliospores of *G. Juniperi-virginianae* and other species of the genus. Heald (1909) working with *G. Juniperi-virginianae* stated that "when germination takes place with a minimum amount of moisture, the promycelium will be short and compact but with an increase in the water supply, a more elongated growth results." Coons (1912) working with this same fungus found that "in air that is partly exhausted of oxygen the germ tubes grew exceedingly long, eight to ten times their normal length, but produced no sporidia. In all cases when returned to air, spores were formed." Reed and Crabill (1915) reported that "an attempt was made to germinate normal teleutospores and sporidia in an atmosphere of carbon dioxide. The spores were suspended in water and incubated for five hours at 18° to 20°C. in an atmosphere of carbon dioxide. No germination took place. They were then incubated for twelve hours in air. Seventy-five percent of

the teleutospores germinated and about fifty percent of the sporidia. After twelve hours exposure to carbon dioxide, sporidia would not germinate under optimum conditions. Oxygen is apparently necessary for the germination of the teleutospores and sporidia." Weimer (1917) stated "these abnormal conditions of germination are usually found where an overabundance of moisture is present or where the temperature is somewhat below the optimum." Miller (1932) found that "an abnormal type of spore germination occurred in high temperatures, in which promycelia were formed, but no basidiospores were developed." Fukushi (1925) working with *G. Yamadae* in Japan, Barclay (1890) studying *G. Cunninghamianum* in India and Blackman (1904) using *G. clavariaeforme* in England, found similar behaviors in the germination of the teliospores and were of the opinion that those teliospores that germinated in an abundance of water usually produced long promycelia.

Many workers have noted the production of secondary basidiospores from the primary basidiospores developed on the basidium. Farlow (1886), Thaxter (1887), Crabill (1913), Reed and Crabill (1915), Weimer (1917) and Miller (1932) have observed this phenomenon. Reed and Crabill (1915) stated "indications are that when kept continually moist from the time of production, the primary sporidia will produce secondary sporidia and that when the primary sporidium becomes dry immediately following its production and subsequently wet, it may germinate either directly or indirectly. The extent of dryness may be the determining factor." Miller (1932) stated that the production of secondary basidiospores could be brought about at will by high temperatures and an abundance of water.

Reed and Crabill (1915) have made some interesting observations on the longevity of the basidiospores of *G. Juniperi-virginianae*. Basidiospores were collected on clean glass slides and kept air dry in the laboratory at a temperature of 15° to 21°C. and were tested daily for germination. They concluded that "five or six days is their life limit in an air dry condition."

Considerable variation was found in the reports on the time required for the production of basidia and basidiospores and the optimum temperatures at which the teliospores and basidiospores will germinate. Heald (1909) stated that "under favorable conditions the promycelium will be produced and the sporidia matured in twelve to twenty-four hours." Fulton (1913) found that from the first swelling of the gelatinous horns to the formation of the infection spores "about 24 hours of moisture were required." Reed and Crabill (1915) observed

that a minimum of four hours was required for the production of the promycelium. Weimer (1917) stated "on one occasion a spore taken from a telial horn had formed a small bud-like process at the end of one hour; after two and one-half hours the promycelium had continued its development and the septa were visible; by the end of three and one-half hours the basidiospores were formed."

Several workers have determined the minimum, optimum and maximum germination temperatures of teliospores and basidiospores of *G. Juniperi-virginianae*. The results of some of these are given below.

Investigator		Teliospores			Basidiospores		
		Min.	Opt.	Max.	Min.	Opt.	Max.
Reed and Crabill	1915	11.5°C.	15°C.	29°C.	8°C.	13°C.	24°C.
Weimer	1917	7°C.	22-25°C.	29°C.			
Miller	1932	4°C.	24°C.	32°C.	8°C.	16°C.	28°C.

Certain workers have reported finding teliospores of *G. Juniperi-virginianae* that germinated with the production of two or three basidia for each cell. Among these may be mentioned Farlow (1880) and Lloyd and Ridgway (1911). It is the finding of other workers, however, that each cell of the teliospore produces but a single basidium.

Little work has been done on the infection of apple leaves by basidiospores. Coons (1912) observed the germination and penetration of germ tubes into apple leaves. He stated that "it was possible to see the hyphae from the sporidia after a vagrant, tortuous growth in the water, bend sharply downward at the edge of the drop and pass into the cell beneath." Coons also noted that "an elongated sterigma penetrated the cuticle of the host directly." Coons inoculated the upper surface of the leaves of one group of apple seedlings and the lower surface of another group. Greater amount of infection resulted from the inoculations made on the upper surface. Weimer (1917) gave an illustration in his figure 141*e* which was described in the text as a germ tube penetrating a cell of the lower epidermis.

To the life history studies as reviewed in the foregoing, I can add little that is new. In the following account of my own work on the aecial phase of *G. Juniperi-virginianae* further studies have been made on certain phenomena and the past and present results are compared and correlated with respect to the relative susceptibility of hosts in the genus *Malus* other than the orchard apples. My own work on the telial phase of this rust includes field observations on the development of the fructifications in Massachusetts as well as laboratory studies on the formation, germination and longevity of the teliospores.

The galls of *G. Juniperi-virginianae* were found to bear numerous yellowish-brown gelatinous telia in April, May and the early part of

June in Massachusetts. During rains of this period the telia absorbed much water and swelled to several times their former volume. When the telia were gelatinized the teliospores germinated and produced vast numbers of basidiospores or sporidia. The basidiospores were wind borne and those that chanced to alight on susceptible parts of pomaceous hosts may have germinated in one to three hours and infected the host and initiated the haploid phase of the rust.

The mycelium of this phase was always clearly visible when stained with the safranin-haematoxylin dyes. It was found among the palisade and spongy mesophyll cells of the leaf and among the cortical cells of the fruits and twigs. The mycelium was uninucleate, 1.5 to 2.5 μ in diameter, and irregular in contour, septate and much branched. It remained localized in the infection areas and increased in amount, up to a certain limit, with the age of infection. From seven to ten days after inoculations were made small discs of mycelium were seen in microscopic section between the upper epidermis and the palisade layer. These discs increased rapidly in all dimensions, and in one to three more days certain of the hyphae at the center of the primordium became apically directed and seemed to act as buffer cells as described by Miss Allen (1930, 1932). These buffer cells seemed to aid in raising the epidermis and at the same time possibly also aided in the increase in diameter of the young spermogonium. The buffer cells soon lost much of their protoplasm and the property of staining deeply with safranin. They stained very lightly in contrast to the heavily stained peripheral hyphae. During and following the loss of their protoplasm the buffer cells also became greatly disintegrated. Deep-staining elongate cells, the spermatiophores and possibly the paraphyses also, were seen pushing towards the center and from the sides and base of the spermogonium. Before the complete disintegration of the buffer cells and most frequently before the ostiole was formed, spermatia were being abstricted from the tips of the spermatiophores. In plate 92 are shown photomicrographs of developing spermogonia.

In leaves of the moderately susceptible species of Malus spermogonia reached the stage of oozing or maturity in from ten to twenty days after inoculations were made. In the more resistant hosts the time required to reach maturity was progressively longer as shown in table II. In the most resistant hosts the spermogonia were seldom observed to have oozed, although they were examined every three days during the entire summer.

At maturity the average size of the spermogonia was 183.7 μ in height by 190.2 μ in width and they were sunken 109.0 μ beneath the

epidermis of the host. The spermogonia of *G. Juniperi-virginianae* is of great diagnostic value. No other in the genus is like it in shape and size. A full account of the morphology of spermogonia of all the species of *Gymnosporangium* is in preparation.

The duration of oozing of the spermogonia varied from a few days to many weeks. The average period of oozing of spermogonia was from seven to ten days, but under certain conditions, particularly in isolated infections, spermogonia continued to ooze for upwards of a month or even longer. Microscopic examination of infected areas on which spermogonia continued to ooze for long periods showed that young spermogonia were being produced among those already dead. Upon the death of the spermogonia they were completely plugged with hyphae and they usually turned black.

The spermogonial exudate of *G. Juniperi-virginianae* had a distinctly sweetish taste. It attracted certain insects. Both red and black ants were often seen swarming over the infected leaves seemingly drinking the nectar. It was interesting to lightly tap a leaf on which the insects had been present for some time. Usually they behaved as if intoxicated; they easily lost their balance, experienced difficulty in getting up and walked aimlessly about. They generally seemed quite contented, however, when they again found an exudate droplet. Thaxter (1887) reported "that small flies were repeatedly observed feeding on the secretion of the spermogonia."

Following the maturity of the spermogonia the mycelium increased vegetatively and occupied wider areas in the infection spots. From forty to fifty days after inoculating irregular yet compact masses of hyphae were observed in the hypertrophied leaf tissue just beneath the palisade layer. With further development these masses of hyphae, the aecial primordia, elongated at right angles to the surface of the leaf. When the primordia reached a certain size the hyphae in the central portion began to disintegrate. From the base of the primordium short-celled binucleate hyphae were seen to grow into the disintegrating tissues. These hyphae soon developed to a plate of regular cells, the hymenium of the aecium. The central cells of the hymenium at first gave rise to peridial cells which penetrated into the disintegrating tissues as a cone of thick-walled cells. Following the production of peridial cells the central hymenial cells gave rise to aeciospores only while the peripheral hymenial cells continued to give rise to peridial cells. These peridial cells joined up with those already formed, that is, the terminal ones, and thus completed the peridium surrounding the aeciospores.

On an average of sixty to seventy days after inoculating, the aecia penetrated the lower epidermis of the swollen cushion and protruded as short acuminate cylinders. In one to three more days the peridium split open and the chains of peridial cells turned outward in characteristic fashion, releasing the aeciospores. The aecia of *G. Juniperi-virginianae* are easily differentiated from most species of the genus, as those of the cedar-apple rust fungus are of the *Aecidium* type. Most other species of *Gymnosporangium* have aecia of the *Roestelia* type which first open irregularly along the sides in cancellate fashion. The peridial cells of this and other species of *Gymnosporangium* are of much diagnostic value as was pointed out by Fischer (1891) and Kern (1910).

The time of maturity of the aecia and the duration of aeciospore production are phenomena that vary directly with the relative susceptibility of the host upon which the parasite is growing. From table VII it will be seen that the aecia reached maturity most rapidly on the most susceptible hosts, and that progressively longer periods were required for the maturity of aecia on the more resistant hosts. The duration of aeciospore production is probably a related phenomenon. In the more resistant hosts the infection spots and the mycelium usually died before the leaves fell. In the very resistant species, *M. fusca* and *M. sylvestris*, many of the infection spots and the mycelium also died early in September in 1932 and 1933. With the death of the mycelium aeciospore production ceased. In the more susceptible hosts most of the infection spots lived and aeciospore production continued throughout the growing season. In the most susceptible hosts, however, aeciospore production continued on many of the infection spots even after the leaves and fruits were picked. On September 24, 1933, leaves and fruit of several of the most susceptible hosts were gathered for the purpose of overwintering the aeciospores. In November and December when these were examined many of the aecia had elongated and aeciospores were clustered in masses about the sori. It was observed, however, that aeciospores were produced most abundantly on the fruits, and only on those leaves that were still green and apparently quite healthy at the time of picking. Thomas and Mills (1929) reported observing this phenomenon on picked apple fruits.

The aeciospores of *G. Juniperi-virginianae* averaged 25.4 μ by 22.0 μ with extreme measurements of 33.0 to 19.8 μ x 26.4 to 16.5 μ. In mass, aeciospores were auburn in color as was determined from Ridgway (1912).

Aeciospores of *G. Juniperi-virginianae* germinated only 1 to 3% in the summer. When gathered in September, 1933, and overwintered in cheesecloth bags they showed only a slight increase in germinability up to January, 1934, and practically no germination thereafter. The aeciospores of this rust are wind borne. They are distributed throughout the summer and many of them must become lodged on the leaves of red cedar trees. No evidence of infection is visible, however, until galls begin to form on the needles of red cedars in June and July of the following spring.

In red cedars the mycelium of the telial phase of *G. Juniperi-virginianae* is found in the infected needles and galls that they bear. The hyphae are binucleate, 2 to 3 μ in diameter, septate and much branched. With increase in the size of the galls the mycelium invaded the new tissues and was found in abundance around all but the epidermal cells. During its vegetative activities the mycelium formed haustoria in adjacent host cells. The haustoria were simple, unicellular, sac-like cells usually with but a single nucleus, but occasionally with two. In plate 98, fig. 5, are shown camera lucida drawings of haustoria of this phase of the rust.

Towards the end of the summer, about August or September in Massachusetts, reproductive activities of the mycelium were first manifested. Beneath each concave depression on the surface of the gall the mycelium formed a stroma of several layers of small, nearly cubical cells. From the stroma a sorus of teliospores was produced. My results agree in detail with those of Dodge (1918) regarding the formation of the teliospores of *G. Juniperi-virginianae*. The uppermost cells of the stroma elongated to several times their former length and lost much of their contents. From the sub-terminal cells a slender hypha was sent into each elongated or buffer cell. These slender hyphae differentiated into teliospores and stalks, as is shown in plate 98, fig. 2. Usually two or three teliospore initials were formed on each sub-terminal cell. These were produced as lateral branches and were not formed within buffer cells. Teliospore formation began near the center of the sorus and progressed peripherally. Thus, spores in all stages of formation could be found at the periphery of the sorus at the base of the telium.

Certain morphological and physiological phenomena of the teliospores are of considerable interest. The wall thickness of 424 teliospores was measured; the measurements fell into three groups, namely, (a) 1 to 1.5 μ thick, 191 spores, (b) 2 to 2.5 μ thick, 49 spores, and (c) 2.5^{+} μ thick, 184 spores. From these results it is seen that the

thick—(2.5+ μ) and thin—(1 to 1.5 μ) walled spores are about equally abundant and that about 15% of the spores have an intermediate wall thickness. Of 1117 teliospores counted from several telia, 1000 or 90% were two-celled and 117 or 10% were one-celled. With rare exception the unicellular spores were thick-walled. Microscopic examination showed that the preponderance of thick-walled spores (both one- and two-celled) was located in the outermost layers of spores in the telium; the inner spores were only thin-walled.

The topographical distribution of the germ pores in the apical cell of the teliospore was also studied. The upper cell had its germ pores either laterally near the septum and one to three were present, or a single germ pore was located at the apex. Rarely was a cell found that had germ pores in both positions. In a count of 310 teliospores, 220 or 71% possessed lateral germ pores, while 90 or 29% possessed apical germ pores. In the basal cell of the teliospore one to three germ pores were located, with rare exceptions, near the septum.

Measurements were made of the top cell, the basal cell, the total length and the width of fifty two-celled teliospores. The measurements were: top cell, 18.8 to 30.0 μ, average 25.4 μ; basal cell, 18.8 to 33.0 μ, average 23.9 μ; total length, 42.9 to 61.0 μ, average 49.3 μ; and width, 16.5 to 23.1 μ, average 18.2 μ. The total length and width of fifty unicellular teliospores measured 33.0 to 49.5 μ × 13.5 to 19.8 μ, average 40.8 μ × 15.2 μ. The unicellular teliospores resembled the two-celled ones in all but the cross wall.

The number of teliospores produced on an average-sized telium is impressively large. An estimation may be obtained by simple mathematical calculations. The average dimensions of a cylindrical telium were found to be 4 cm. long by 4 mm. in diameter, and the two to four (two to be conservative) peripheral layers of teliospores in close contact measured on the average 49.3 μ × 18.2 μ. Calculations showed the number of teliospores in a single telium to be about 22,300,000. The number of basidiospores is naturally many times greater, theoretically up to eight times as many. Thus a single small gall bearing six telia (an average number for a small gall) produces about one billion basidiospores, an average-sized gall with fifty telia about eight billions, and a large gall upwards of sixty billions.

For the purpose of testing the effect of water and air on the germination of teliospores of *G. Juniperi-virginianae*, telia were first wetted in water and placed on dry glass slides in a moist chamber and examined *in situ*. Those teliospores next to the slides were naturally wholly immersed in water and so excluded from a ready supply of air, while those not in contact with the glass were covered by a thin film of water

only and so were more accessible to air. Many of the teliospores that were immersed in water produced long germ tubes, while the others developed both basidia and basidiospores.

It has been the writer's experience to find that teliospores from young telia produced basidiospores within three to four hours; but as the telia aged the time required for germination of the older spores increased. The time required for germination of teliospores kept in a refrigerator was determined. In October approximately eighteen hours were required for the production of basidiospores, while in February only a small percentage of the teliospores germinated at the end of thirty-six to forty-eight hours and a few of these produced basidiospores.

After the production of one crop of telia the gall and the mycelium in it usually died. Rarely, however, the growth of the gall and the mycelium were continued and a second crop of telia was produced. In plate 97, fig. 2, is shown a small gall of *G. Juniperi-virginianae* that produced one crop of telia and survived for another season. In plates 96, 97 and 98 are shown photographs and drawings of galls and telia in various stages of development.

VII. BIOLOGICAL STRAINS OF G. JUNIPERI-VIRGINIANAE

Several workers have cultured *G. Juniperi-virginianae* from various localities upon a few species of *Malus*, including several varieties of orchard apples, but their findings are not in harmony.

Stewart and Carver (1895) obtained telial material of *G. Juniperi-virginianae* from Iowa and New York and made cultures on varieties of orchard apples. They found that on most of these the fungus developed essentially the same. A slight difference was reported, however, for Red Pippin—no aecia were produced by the fungus from Iowa, but aecia were partially developed by the fungus from New York. Pammel (1905) found no biological strains in telial material from Missouri and Long Island, New York. Arthur (1905) found no difference in the rust from North Carolina or Iowa when cultured on orchard apples. Weimer (1917) cultured the rust from Nebraska, West Virginia and New York on Wealthy apples in the open and on seedling apples in the greenhouse. "In no case was there any evidence to show that one strain was more virulent than the other." Bliss (1928, 1933) on the other hand, showed that biological strains existed within the state of Iowa. He also found biological strains from Kansas, West Virginia, New York, Wisconsin and Ontario.

In order to further investigate this phenomenon, inoculation experiments were made on forty-five species of the genus *Malus* in the

Arnold Arboretum in the season of 1933. Telial material of *G. Juniperi-virginianae* was obtained from eight localities in the United States, namely, Alabama, Kentucky, Massachusetts, Michigan, Missouri, Nebraska, New York and West Virginia. All of the inoculations were made early in the growing season and within a period of one week. The results showed marked differences in the virulence of the parasite from each of the eight states. According to my results biological strains of *G. Juniperi-virginianae* do exist. The data are presented in table VII. The aecial hosts are arranged in order of decreasing

TABLE VII.

RESULTS OF THE INOCULATIONS ON THE POMACEOUS HOSTS IN THE GENUS MALUS WITH G. JUNIPERI-VIRGINIANAE FROM EIGHT STATES—A TABULATION OF THE NUMBER OF DAYS REQUIRED FOR THE DEVELOPMENT OF THE AECIA

	Mass.	Nebr.	Mich.	N. Y.	Mo.	Ky.	Ala.	W. Va.	Averages
MALUS									
ioensis plena	52	h	61	53	61	60	lost	dd	59
Soulardi	52	h	h	53	h	64	64	70	60
coronaria	56	60	65	60	lost	61	64	68	62
lancifolia	56	60	61	59	68	dd	66	65	62
angustifolia	56	61	64	63	56	68	66	69	63
glaucescens	56	62	60	59	62	69	65	71	63
platycarpa	63	60	61	59	66	66	70	68	64
glabrata	63	60	62	64	dd	00	71	72	65
bracteata	59	62	64	67	76	lost	dd	74	67
ioensis	60	h	h	63	h	69	70	76	68
Dawsoniana	69	00	00	76	00	00	00	00	72
sylvestris	65	h	00	71	00	00	73	82	73
fusca	75	00	h	73	h	h	h	h	74
Averages	55	60	62	63	65	65	68	70	

h — hypersensitive
dd — inoculated branch died
00 — no infection resulted

susceptibility and the states are arranged in order of decreasing virulence of the parasite as indicated by the average number of days required for the maturity of the aecia. From this table it will be seen that the rust from Massachusetts matured its aecia in an average of 55 days and that the fungus from the other states required progressively longer periods; that from West Virginia required the longest time, namely, 70 days. It will also be observed that the rusts from Massachusetts and New York were the only ones to parasitize all of the aecial hosts. The strains from Nebraska, Michigan and Missouri failed to produce aecia on *M. fusca, M. sylvestris, M. Dawsoniana, M. ioensis* and *M. Soulardi.* It is of interest to note that the hybrid *M. Soulardi* (*M. ioensis* × *pumila*) reacted to infection by the rust from each of these states, as did the susceptible parent *M. ioensis.* The hybrid *M. Dawsoniana* (*M. fusca* × *pumila*) was parasitized only by the same rust strains as was the susceptible parent *M. fusca.* In *M. fusca,* however, the rust strains usually produced infection, but the rust and the infected areas died before the production of aecia. Likewise it is of interest to note that on the average (with one exception in each of the two hosts) the strains of the rust from each state produced aecia on the hybrids *M. Dawsoniana* and *M. Soulardi* in shorter time than on the parent species *M. fusca* and *M. ioensis.* The presence of biological strains of this fungus in various geographical areas may be an important factor in accounting for the variable reports on the relative susceptibility of orchard apples received from several states.

VIII. OBSERVATIONS ON FACTORS INFLUENCING THE AMOUNT OF INFECTION ON HOSTS OF G. JUNIPERI-VIRGINIANAE

The topic of this section is in part expressed by the term epiphytology as defined by Whetzel (1925), namely, "that phase in the study or discussion of a disease which deals with relation of environmental factors to its occurrence, severity and character. These factors are chiefly climatic, soil and cultural. They influence the disease indirectly through their influence on the pathogene or the suscept or both." But it is somewhat broader still because it includes factors inherent in the constitution of the host and in the pathogen. Undoubtedly the inherent constitutions of both the host and the pathogen have an important influence on the "occurrence, severity and character" of the disease. That this is so is shown by the results of the inoculations as recorded in table VII. The importance of external environmental

factors, however, is not minimized. The influence of factors of both kinds have been studied and I now pass to a description and discussion of the results observed. Greater strength is added to the exposition by including corresponding observations relative to various *Gymnosporangium* diseases other than those caused by *G. Juniperi-virginianae*. The findings herein reported are largely field observations made during the present investigation. In certain instances, however, examples by previous investigators are discussed and hypothetical cases are constructed from combinations of possibilities.

(A) Relation of the location of the source of inoculum to the amount of infection on Malus spp.

The location of the source of inoculum has a pronounced influence upon the amount of infection. Certain localities facilitate distribution of the inoculum, others hinder it. The transfer of inoculum is influenced by such features as distance, bodies of water, elevation of the source, intervening bodies and wind.

The distance that the inoculum must travel before reaching a host, if short, usually facilitates distribution of the fungus. Planting aecial and telial hosts in close proximity creates ideal conditions for the continuation of the rust when once established. Such plantings have been frequently met with in home gardens and on large estates. The same scheme has been carried out on an extensive scale in several of the midwestern states where red cedars are used as windbreaks around apple orchards.

Large bodies of water also are usually an advantage to the dispersal of the inoculum. Thaxter (1887) recorded an instance in which basidiospores of *G. biseptatum* Ellis infected chokeberries, *Aronia* sp., eight miles from the only source of inoculum known to him. The source of inoculum was infected branches of *Chamaecyparis thyoides* B. S. P. on an island off the coast of Maine. While my investigations were in progress, Mr. J. D. MacLachlan (who grants permission to report the observations made) found certain shad bushes and hawthorns that were infected with both *G. clavipes* and *G. globosum*. After an intensive search of the surrounding territory it was determined that the only source of inoculum was six to seven miles from the infected plants. The basidiospores of these rusts travelled chiefly over water and were probably aided by the greater humidity and the unobstructed area.

The height of the source of inoculum seems to favor a greater distribution of the fungus. Bartholomew (1912) described a case in

which susceptible apple trees were variously located with respect to a bluff on the top of which were infected red cedars, namely, (a) one group at the base of the bluff, (b) one group one-fourth mile distant, and (c) a third group one mile distant. It was determined that the percentage of infected leaves was 60%, 55% and 7% respectively for the three groups of apple trees. While the trees one mile distant were but 7% infected it is to be borne in mind that trees at that distance are generally presumed to be outside the range of distribution of the basidiospores of *G. Juniperi-virginianae;* this belief is reflected in the recommendations regarding cedar eradication, that is, that eradication for a radius of one mile protects apple trees. Unquestionably the greater range in the instance recorded by Bartholomew is related to the relative height of the inoculum.

Within limited distances, however, certain barriers may serve to confine the inoculum. Thus if red cedars harboring the inoculum are surrounded by taller trees the spores tend to be retained within a small area. A striking example of this is given by Giddings (1918). He described a large grove of infected cedars growing close to a row of susceptible apple trees. "A strong wind was blowing from this grove into the orchard at the time of infection, and the effects of the disease appeared to be at least twice as severe on the side toward the cedar grove as on the other side." From this example it seems that many basidiospores were lodged and so prevented from travelling through the trees. In my own investigations many similar instances have been observed. On the Lyman estate, Canton, Mass., two groups of red cedars and shad bushes were growing about two hundred yards apart. The red cedars and shad bushes in one group were heavily infected with *G. clavipes* C. & P., while the plants in the other group were heavily infected with *G. Nidus-avis* Thaxter. Both of these groups were surrounded by high cedars, beeches and pines. Enormous numbers of spores were produced each year on the heavily infected hosts in each group. The contagion, however, was held within the group and only occasionally did the inoculum from one group reach the other. Another example may be cited. In an old pasture off Trapelo Road, Waltham, Mass., two small groups of apple trees were surrounded by red cedars. The cedar trees were also abundant over the rest of the pasture. *G. Juniperi-virginianae* was unusually plentiful on the apple trees in each group. The nearest cedar trees were literally covered with galls. Progressively farther from the apple trees the number of galls on the red cedars rapidly decreased. At about one hundred feet distant only a few scattered galls could be found. This phenomenon seems to be due in part to the reduced carrying capacity of the wind

because of progressively decreased rates of travel through the trees and in part to the fact that branches and leaves of the barrier trees presented a large surface to which the spores could adhere, leaving fewer to be carried further. These two factors acting together are sufficient to account for the limited range of spore distribution in plantings that are surrounded by taller trees.

The direction of the wind at the time of spore production necessarily governs to a considerable extent the direction of spore dispersal. Apple trees that are in the windward direction are liable to receive a greater number of spores and thus may become more heavily infected than those in the leeward direction.

(B) The influence of age and wounds on liabiliaty to infection.

It has previously been shown that the leaves of many species and varieties of *Malus* are susceptible for a certain interval only during their youth. Because of the shortness of this period the less susceptible hosts are more protected by virtue of this phenomenon. As many of the orchard apples are only slightly susceptible, this fact assumes important, practical significance. Giddings and Berg (1915), however, noted that fully mature leaves of certain apple varieties sometimes became infected through insect injuries. Miller (1932) inoculated wounded and unwounded leaves of resistant varieties of apples. He obtained infection on only the wounded margins of the leaves. In my own work, fully mature leaves of *M. ioensis plena* that were quite past their period of susceptibility were cut in several places with a knife. Some of them were inoculated immediately. The next day more of the cut leaves and several of the uncut ones of approximately the same age were inoculated. Upon later examination it was found that those leaves that were cut and inoculated immediately became infected along the margins of the cuts but remained practically free from infection between the cuts. Those leaves that were not cut and those leaves that were cut one day and inoculated the next showed only slight evidence of infection. As a practical example, we may find hosts past their period of susceptibility that become infected after being wounded during rain storms in which basidiospores were dispersed.

(C) Influences of spring weather conditions on pomaceous hosts and on the telia of the rust.

In Massachusetts the telia of most species of *Gymnosporangium* appear about the first of April. The teliospores are germinable immediately or shortly after their appearance. Buds of most of the pomaceous hosts, however, do not appear until two to four weeks later.

The temperatures and the amount of rainfall during this period are very important. Should the rains be heavy and frequent, many of the teliospores will have germinated and come to naught because the susceptible parts of the alternate hosts are still enclosed in the buds. Should this period of wet weather be followed by a dry period, during which the buds open and pass their stage of susceptibility, little infection would probably result from subsequent rains. Warm rains between 15°C. and 24°C. when the buds are unfolding and the leaves expanding probably favor the fungus, as it has been shown that basidiospore production reaches a maximum between these temperatures.

The structure and development of the telium greatly influence teliospore production. It will be shown that the telium of *G. Juniperi-virginianae* adds a cylinder of fresh spores at its base during each of six or seven gelatinizations in the spring. The chances for successful infection by rusts with this type of telium is favored by the fact that the production of inoculum is distributed over a long period of time. This method of development seems to be restricted to species of *Gymnosporangium* with telia of the columnar type. Those species with low pulvinate telia, as *G. clavipes*, usually fully expose their sori after two or three rains. Although the spores do not all germinate at one time, nevertheless, by the end of two or three subsequent rains the telia have fully gelatinized and dropped from the branches.

(D) The influence of health of pomaceous hosts with reference to their liability to infection.

The health of pomaceous hosts seems to influence the amount and development of infection. In the Arnold Arboretum several small plants of *M. ioensis plena* were heavily infected with cedar-apple rust in the spring of 1931. That fall the trees were moved to a new location. The next spring they seemed to be in rather poor health. Both natural and artificial inoculations resulted in few and smaller than average infection spots. In the summer of 1933 the infection spots were larger and more numerous. In 1934 the infection spots were equally as numerous and fully as large as those on long established individuals of the same variety. From these limited observations it seems that the poorer health of the trees may account for the decrease in the size and number of rust spots.

(E) The influence of the presence of more than one species of Gymnosporangium on the susceptibility of infected plants and organs of Malus spp.

The presence of one species of *Gymnosporangium* does not exclude the possibility of other species growing on the same host or even on the

same organ. Many examples of more than one species growing in close proximity have been observed. *Gymnosporangium clavipes* and *G. globosum* were frequently found on the same individual of *Crataegus*. *Gymnosporangium Juniperi-virginianae* and *G. Nidus-avis* were successfully cultured on the same leaves of several species of *Malus*. Mature aecia of *G. clavipes* and *G. Nidus-avis* were sometimes found on the same fruit of *Amelanchier oblongifolia*. Many similar examples could be cited, but these will suffice.

Several phenomena have also been studied with relation to their influence on the amount of infection caused by *G. Juniperi-virginianae* on red cedars. These include the phenomena of sex, twig growth, presence of more than one species of *Gymnosporangium* and the duration of aeciospore production.

(F) The influence of sex of red cedars on infection by Gymnosporangium.

Reed and Crabill (1915) reported that many farmers were of the opinion that pistillate cedars only became infected with *G. Juniperi-virginianae*. After examining many trees of each sex—a total of two hundred ninety-three trees—they state that their notes "show conclusively that sex does not influence infection" of red cedars. In extending observations on this phenomenon, a survey of red cedar trees was made in areas around Boston where *G. Juniperi-virginianae*, *G. clavipes*, *G. Nidus-avis* and *G. globosum* were very common. Male and female trees were about equally abundant in these areas. The results show clearly that trees of each sex were attacked by each of these species of *Gymnosporangium*, and no preponderance of infection was noted for either sex.

(G) The influence of the presence of more than one species of Gymnosporangium on the susceptibility of red cedars.

Simultaneously with the foregoing survey data were recorded relative to each species of *Gymnosporangium* that was found on red cedar trees. In table VIII are presented data on this survey. The results show that nearly all possible combinations of the four species of *Gymnosporangium* were found on trees of each sex. Not only were two or more species of *Gymnosporangium* found on the same tree, but also several species were found growing on the same branch. Small branches of red cedar were frequently observed to be infected with galls of *G. Juniperi-virginianae* and *G. globosum*. Branches were also found with *G. clavipes* and one or both of these gall forms. A twig of *J. virginiana* was found on which two adjacent leaves were infected,

one with *G. Juniperi-virginianae*, the other with *G. globosum*. Perhaps the most striking instance of the close association of two species of *Gymnosporangium* was a small witch's broom caused by *G. Nidus-avis* that had on its twigs no fewer than fourteen galls of *G. Juniperi-virginianae*. From these observations it may be stated as a general principle that the presence of one species of *Gymnosporangium* does not necessarily exclude the possibilities of other species growing on the same tree or even on the same branch or twig.

TABLE VIII.

THE INFLUENCE OF SEX AND THE PRESENCE OF MORE THAN ONE SPECIES OF GYMNOSPORANGIUM ON THE SUSCEPTIBILITY OF RED CEDARS

Sex of red cedar	J-v	c	g	N-a	J-v,c	J-v,g	J-v,N-a	c,g	c,N-a	g,N-a
Female	15	1	0	0	1	6	14	5	0	0
Male	15	1	2	1	2	2	4	3	0	0
Undetermined	13	3	2	1	1	2	5	3	1	1
Totals	43	5	4	2	4	10	23	11	1	1

Continuation of table 8

J-v,c,g	J-v,c,N-a	J-v,g,N-a	c,g,N-a	J-v,g,c,N-a	Imm.	Totals
3	2	0	0	2	4	53
2	2	0	0	2	1	37
4	4	0	0	1	10	51
9	8	0	0	5	15	141

J-v — *G. Juniperi-virginianae* Schw.
c — *G. clavipes* C. & P.
g — *G. globosum* Farl.
N-a — *G. Nidus-avis* Thax.
Imm. — Immune.
The figures refer to the number of red cedars observed.

(H) THE DURATION OF AECIOSPORE PRODUCTION IN RELATION TO INFECTION OF RED CEDARS.

The number of aeciospores produced is largely governed by the size, the abundance and the rate of production of the aecium. Of the rate of production practically nothing is known. Observations have been made, however, on the comparative sizes of the aecia as well as on the duration of their activity. On very susceptible varieties as *M. ioensis*

plena and *M. coronaria Charlottae,* the aecia were relatively numerous and aeciospore production of *G. Juniperi-virginianae* continued throughout the growing season. In fact it was found that aeciospores continued to be formed even after vigorous leaves and fruit were picked in the fall. Thomas and Mills (1929) also observed this phenomenon on apple fruits. On the less susceptible hosts, however, the size of the aecia was smaller, their numbers fewer and aeciospore production continued for shorter periods. On *M. fusca* and *M. Dawsoniana,* for example, infection spots usually died and aeciospore production ceased early in September.

Another example of this phenomenon is shown in the case of *Amelanchier oblongifolia* and *Crataegus mollis,* both of which were about equally infected about the same time with *G. clavipes.* The fruit of *A. oblongifolia,* as is also true of other species of *Amelanchier,* ripened and dropped off about July 15, at which time aeciospore production ceased. The fruit of *C. mollis,* however, did not ripen until about September 1 and aeciospore dissemination continued throughout this time. Thomas and Mills (1929) have shown that aeciospore production of *G. clavipes* may continue on the fruits of apples even after they are picked. The fact that aeciospore production may continue after the leaves and fruit have fallen suggests at once the cultural treatment of destroying all infected litter under the trees as an aid to controlling the rusts.

IX. CONTROL OF G. JUNIPERI-VIRGINIANAE ON APPLES AND ON RED CEDARS

Heretofore, control of the cedar-apple rust disease has been concentrated almost exclusively on commercial orchards. Two methods have been tested, namely, control by the use of fungicides and control by eradication of red cedars. Investigations on fungicidal control measures have been fairly numerous but they have not been adopted, partly because experimenters failed to find satisfactory ones and partly because of the instant success that followed the eradication of red cedars. In spite of the fact that cedar eradication measures have been very successful such objections have been raised, in almost every region where eradication was attempted, as to defeat the efforts towards enforcement. At the same time little progress has been made toward working out and popularizing fungicidal control measures. Interesting as is this situation with regard to the present status of cedar-apple rust control in commercial orchards, the immediate stimulus of my own work as stated in the introduction of this paper, lay in demands for

information on the control of this fungus on ornamental apples and red cedars, a phase which has so far received little or no attention. In this connection, of course, red cedar eradication in most cases would automatically be ruled out. Naturally it is hoped that if this phase of the problem can be solved, adaptations feasible in commercial orchards will follow. An account of my work is prefaced by a brief review of the literature on control in commercial orchards.

1. HISTORY OF THE CONTROL OF THE RED CEDAR-APPLE RUST FUNGUS.

(a) Control by eradication of red cedars.

In 1888 Professor B. T. Galloway (1889), after observing the ineffectiveness of sprays to control *G. Juniperi-virginianae* on apple hosts wrote, "As a remedial measure it passes without further comment that it is well to destroy all specimens of the red cedar or savin." This is the earliest record found recommending the eradication of the red cedar.

Jones (1892, 1893) reported a practical test of eradication of red cedars. He stated, "In the fall and winter of 1891-1892, all the red cedars were destroyed in this (Vermont) orchard for a radius of one mile around. The results were magical. In former years, many of the trees were entirely defoliated by rust in August; the past summer not a rusted leaf was found in the entire orchard."

Reed, Cooley and Crabill (1914) recommended a cedar-free area of one-half mile around apple orchards in Virginia.

Giddings and Berg (1915) gave considerable data on the cost of eradicating red cedars in West Virginia; they came to the conclusion that "the actual cost of removing cedar trees for a radius of one mile around an orchard of six hundred or more susceptible trees would be equal to the fruit loss which might be expected to occur in one season as the result of a severe infection of apple rust." An area including 1,113 acres was cleared at an expenditure of $532.68 which was about 48 cents per acre.

Jones and Bartholomew (1915) strongly advised the removal of red cedars as the most certain and most practical means of controlling *G. Juniperi-virginianae* in Wisconsin.

Fromme (1918) made a strong appeal for the adoption of a cedar eradication law in Virginia. According to his estimates the cost of a single spray application in Frederick County (Virginia) in 1917 was about $3.00 per acre; while the cost of removing red cedars was shown to be about $2.50 per acre of apple trees. "As cedar eradication has been enforced in this county for four years," Fromme says, "the growers of Frederick County, if my figures are reasonably accurate,

have had four years protection from cedar rust at the cost of a single spray application." In oratorical language Fromme continues, "The question is often asked, 'Is there no spray for cedar rust?' Why in the world would anyone want to spray for cedar rust? It is cheaper to cut down the cedars. Cedar eradication is the cheapest form of orchard insurance you can buy. The cost, on the average, is less than the cost of a single spray application."

Stewart (1920) is of the opinion that orchardists of New York should coöperate and by persuasion remove as many as possible of the cedar trees from about their orchards.

Talbert (1925) recommended that cedars be removed from one-half to two miles around commercial orchards in order to successfully control this fungus under Missouri conditions.

McCubbin (1929) advises the removal of red cedars for a minimum of one-half mile from orchards in Pennsylvania. He also recommends the destruction of all native wild apples from nearby orchards, a very important recommendation.

As a result attendant on propaganda favoring red cedar eradication many apple-growing states enacted some form of law whereby eradication of red cedars could be enforced. Two forms of these laws exist: (a) cedar eradication laws and (b) general plant pest laws. States having these laws are listed below and they are graphically shown in fig. 2.

States having a cedar eradication law	States that have a general plant pest law under which cedar eradication has been enforced
Arkansas	Delaware
Kansas	Illinois
Nebraska	Minnesota
New York	Pennsylvania
Virginia	Wisconsin
West Virginia	

In order to satisfactorily protect apple trees an area of at least one mile in radius around commercial orchards must be free from red cedars. To clear such an area it is usually necessary to remove cedar trees from the land of property owners other than that of the orchardist. This is where the main difficulty arose. Property owners within this area often strenuously objected to their cedar trees being removed to protect neighboring orchards. So numerous and so strenuous have been the objections that in many states the cedar eradication laws are no longer enforced. In Nebraska a case was taken to the Federal District Court of Omaha and aroused so much ill-feeling that it seemed

unwise to continue the enforcement of the law in that state. Quoting from a letter received recently from New York, "There is a cedar eradication law on the books in this state, but at the present time very little effort is being made to enforce it since the chief problem is in the Hudson Valley where large estates are involved and law suits are sure to follow any attempt to eradicate the cedars." One from Illinois reads, "The state attempted to enforce eradication in a limited area but with indifferent success. In some of the states, however, as Kansas and West Virginia, I am told that cedar eradication is being carried out with very good results but often under great opposition.

FIGURE 2. Location of states in which cedar eradication laws (indicated by lines sloping northeastward) or general plant pest laws (indicated by lines sloping northwestward) have been enforced as a means of controlling *G. Juniperi-virginianae*.

(b) Fungicidal control on apples and on red cedars.

In 1888 Col. A. W. Pearson in New Jersey sprayed two apple trees, one with sulfate of iron, and one with Bordeaux mixture. The sprays were applied every three weeks until July 22. Of the first tree he remarked, "At the close of the experiment the trees were as badly affected as at any previous year." Of the second tree Professor B. T. Galloway said, "The foliage remained fairly healthy, yet the benefit resulting was not sufficient return for the labor expended." So far as I have learned this is the earliest recorded attempt to control *G. Juniperi-virginianae*. It was reported in Professor B. T. Galloway's Annual Report of the U. S. D. A. of 1889, and also in a paper by Professor Galloway in 1890.

Jones (1891) sprayed apple trees with ammoniacal copper carbonate on May 17 and 30. The results showed no marked difference in the percent of rusted leaves, but the number of rust spots per leaf was somewhat reduced.

Pammel (1891) reported that he sprayed apple trees with Bordeaux mixture and ammoniacal copper carbonate. Bordeaux was applied twice and the third application was of ammoniacal copper carbonate. He says, "The spraying had apparently no effect on the fungus; it was about as severe on the sprayed trees as on the check."

Emerson (1905) sprayed several apple trees with 4:4:50 Bordeaux and obtained very good control. He stressed that it was essential to spray at the time when the telia were gelatinized and that spraying at other times was useless.

Hein (1908) reported the results of three years of spraying apple trees with Bordeaux mixture. "During the present season, cedars were carefully watched. After each gelatinous state of the cedar apples, the apple trees under experimentation were thoroughly sprayed. This spraying was done as soon as the rain, which caused the swelling of the cedar apples, ceased. The most we can say in favor of the spraying is that the amount of rust may have been very slightly reduced."

Waite (1910) used many spray materials in experiments on the control of cedar-apple rust and other foliage diseases of the apple. He summarized the results by stating that "all the fungicides protected the trees almost completely from fungous diseases."

Bartholomew (1912) obtained fairly good control by spraying apple trees with Bordeaux 4:4:50 and 3:3:50 immediately following the gelatinization of the telia. He insisted that, "The crucial time for action depends entirely upon such weather conditions as favor development of the cedar galls." In this work he sprayed three orchards: one, close to cedar trees; a second, one-quarter mile from cedar trees; and a third, one mile from cedar trees. He tabulated the number of sprayed and unsprayed leaves affected in each orchard and showed a marked reduction in the number of infection spots by spraying.

Giddings and Neal (1912) in a preliminary report stated that they found Bordeaux mixture, lime sulfur and atomic sulfur valuable in the control of *G. Juniperi-virginianae*. The quantity and the quality of the fruits of certain varieties was much higher on sprayed than on unsprayed trees. They found, too, that the time of application was of much importance in spray control work. It was, however, possible to control the disease to some extent by a single application.

Giddings and Berg (1915) stated that "our work thus far has shown that apple rust may be controlled by spraying." They found lime sulfur 1:40 and Bordeaux to be about equal in value and much better than atomic sulfur. They add, however, that it seemed impracticable to control this disease in commercial orchards by use of liquid sprays. They state further that the spraying must, of course, be thoroughly done, and "the impracticability of carrying out such a spray schedule (as six to seven applications) in a large orchard is self-evident."

Reed, Cooley and Crabill (1914) and Reed and Crabill (1915) experimented with several fungicides on the control of cedar rust of apples. They stated that "copper lime sulfur was by all odds the best fungicide employed in this experiment. It gave practically clean foliage and produced no spray injury either to foliage or fruit."

Fromme and Thomas (1917) applied a "superfine" sulfur dust to apple trees in an attempt to control *G. Juniperi-virginianae,* but were entirely unsuccessful in these experiments.

Heald, in 1909, reported the first attempt to control *G. Juniperi-virginianae* by spraying red cedars. "It is obvious that the spraying might be designed to kill the teliospores, and so should be made to prevent the reinfection of the cedar. Germination tests made from the teliospores of the telia sprayed with 5:5:50 Bordeaux showed the complete failure of the teliospores to produce sporidia. It does not seem, however, that spraying at this period will ever be practical. Some carefully planned spraying experiments to prevent the reinfection of the cedar were carried out during the season of 1907. The results showed that spraying at intervals from the period of maturity of the aecia to September 1 very greatly reduced the number of cedar apples. The reduction of number of galls is not sufficient to be of much value in preventing the infection of adjacent apple trees, but if the life of valuable cedars is being threatened, spraying should reduce the ravages of the fungus sufficiently to prevent any material injury to the cedars."

2. My studies and observations on control measures.

My studies in this connection were based almost exclusively on fungicidal means of control. The problem included an exploratory investigation of numerous fungicides with respect to their control value on both apple trees and red cedars. The most promising of these fungicides was then tested on an extensive experimental scale on numerous trees under various weather conditions. The fungicide was applied to

red cedars (a) to prevent germination of the teliospores, (b) to protect cedars from infection by aeciospores, and (c) to apple trees as a protection against basidiospore infection.

(a) On red cedars to prevent germination of teliospores.

On the Lyman estate, Canton, Massachusetts, *G. Juniperi-virginianae* was in very great abundance and exploratory tests with several fungicides were made there. In table IX are enumerated the sprays that were used in these tests.

TABLE IX.

SPRAY AND DUST MATERIALS USED IN EXPLORATORY TESTS

Bordeaux	3:3:50, 4:4:50, 6:6:50
Linco colloidal sulfur[1]	¼%, ½%, 1%, 2%, 3%
Lime-sulfur	1:30, 1:40, 1:50, 1:70
Soluble palustrex[2]	1%, 2%, 3%, 4%
" " A.	" " " "
" " B.	" " " "
" " C.	" " " "
Sunoco oil[3]	2%, 4%
50% Sunoco oil and 50% soluble palustrex	2%, 4%
50% Sunoco oil and 50% soluble palustrex B.	2%, 4%
80% Sunoco oil and 20% copper resinate	2%, 4%
80% Sunoco oil and 20% soluble palustrex	2%, 4%
Kolo base	
Kolo dust	
Pomo green	
Sulfur dust	

[1]Obtained from Linder and Co., 296 North Beacon St., Boston, Mass.
[2]Obtained from E. W. Coolidge, Jacksonville, Florida.
[3]Obtained from Sun Oil Co., Boston, Mass.

All of these spray and dust materials were first applied to potted red cedars in the greenhouse in the spring. None of them caused burning of the young foliage. In the field the sprays were applied to the galls as follows: (1) before the telia had emerged from the galls, (2) just after the telia had emerged, and (3) after one, two or three gelatinizations of the telia, but always when the telia were dry.

Telia to which the sprays were applied were brought into the laboratory for examination; smear slides were made of the spores and exam-

ination was completed shortly after their arrival. It was not the purpose of this examination to determine the relative value of each spray, rather the purpose was to determine which ones would prevent germination of the teliospores. The most satisfactory sprays were soluble palustrex B at 4% and Linco colloidal sulfur at 1%, 2% and 3%. In testing these sprays further it was found that this colloidal sulfur at 2% and 3% was most constant in its reactions. Colloidal sulfur was, therefore, chosen for the experimental work that followed. It should be added, however, that colloidal sulfur at 1% greatly reduced the amount of germination; colloidal sulfur at 2% completely prevented germination of the teliospores of *G. Juniperi-virginianae*. Colloidal sulfur at 3%, therefore, was unnecessary.

In April 1933, many telia of *G. Juniperi-virginianae* were sprayed upon their first appearance with colloidal sulfur at 1% and 2%. The effect of the spray was determined by gathering several sprayed and unsprayed telia three days after they were sprayed, thoroughly wetting and keeping them in a moist chamber over night. When germination was abundant a spore print would result, but when no spore print was formed a smear slide was made and the teliospores examined under the microscope. The unsprayed teliospores always germinated in abundance. Teliospores sprayed with 1% colloidal sulfur germinated to some extent, but few basidiospores germinated. Telia sprayed with 2% colloidal sulfur showed no germination of the teliospores.

After the rain following each spraying, telia were again gathered and immediately tested. The controls germinated in abundance. The telia sprayed with colloidal sulfur at 1% and 2% germinated to a slight extent. Some change was called for in order to control this small amount of germination. Certain substances were used to lower the surface tension of the spray material which might aid its penetration into the telium. Spreaders were tried but with no success.

Microscopic sections were cut from dry and wet telia and examined in a minimum of water. The structures of the telium gave a clue to a new line of experiment. The telia, it will be recalled, are made up of an outer zone which contains most of the teliospores and an inner and larger zone which contains teliospore stalks largely. To be of most value, therefore, the particles of spray materials should be located on the outside of the telium on or near the teliospores. The next step, therefore, was to find a sticker and spreader so that the sulfur particles might be held on the teliospores or within the spore containing zone. Calcium casienate was the only one used. Again a

new lot of telia were sprayed with colloidal sulfur 2% plus ¼% calcium casienate. Telia were tested in the laboratory and gave positive results for the controls and negative results for those sprayed. Following a heavy rain control as well as sprayed telia were examined for germination. All unsprayed telia germinated in great abundance. Examination of the sprayed telia of *G. Juniperi-virginianae* showed that teliospores in the sprayed portion of the telium did not germinate but that an additional basal portion of the telium which had not been touched by the spray had emerged from the gall, and the teliospores in this portion germinated in abundance. Following another heavy rain sprayed and unsprayed telia of *G. Juniperi-virginianae* were collected for immediate examination. The controls germinated in great abundance. The sprayed portions of the telia showed, after these two rains, no germination of the teliospores. An additional part of the base of each telium had emerged in this rain. The teliospores in this new portion of the telium germinated in great abundance. Photographs of telia which were sprayed and later subjected to rains are shown in plate 96, figs. 5 and 6. From these observations and data it was concluded that in order to successfully control these rusts by spraying on the red cedar it was necessary to spray the telia after each rain with colloidal sulfur 2% plus ¼% calcium casienate.

(b) On red cedars as a protection against infection by aeciospores.

Investigations on this means of controlling *G. Juniperi-virginianae* are now in progress. However, no experimental data are yet available with respect to the value of spray applications on red cedars.

(c) On ornamental apples as a protection against infection by basidiospores.

In the summer of 1932 certain of the most susceptible species of *Malus* were sprayed in an effort to determine the relative values of soluble palustrex B and colloidal sulfur. Branches of *M. coronaria Charlottae* and *M. Soulardi* were sprayed with soluble palustrex B at 1% and 2%, and other branches were sprayed with colloidal sulfur ¼% and ½%. The next day, all of the sprayed branches and four control branches on each tree were heavily inoculated with basidiospores of *G. Juniperi-virginianae* by the usual method. The results are given in table X.

From these data it was concluded that colloidal sulfur at ½% was the most efficient spray material with which to protect aecial hosts.

Since sulfur and sulfur compounds have proven to be effective generally in controlling rusts, it was decided to concentrate on the use of colloidal sulfur during the next season.

TABLE X.

RESULTS OF SPRAY EXPERIMENTS WITH COLLOIDAL SULFUR AND SOLUBLE PALUSTREX B

	col.sulfur ½%		col.sul.¼%		sol.pal.B 2%		sol.pal.B 1%	
Test trees	no. lvs. inoc.	no. infection spots	no. lvs. inoc.	no. inf. spots	no. lvs. inoc.	no. inf. spots	no. lvs. inoc.	no. inf. spots
Malus Soulardi	21	4	22	8	26	16	25	6
coronaria Charlottae	21	2	26	50	28	50	20	100
Totals	42	6	48	58	54	66	45	106
Controls	All leaves heavily infected							

In the spring of 1933 extensive control experiments were conducted on certain of the most susceptible species of the genus *Malus*. Convenient portions of the trees were sprayed with colloidal sulfur ½% and the remaining portion served as controls. A total of 250 inoculations were made on the sprayed and unsprayed branches. The results of these tests showed conclusively that colloidal sulfur at ½% gave excellent protection to the leaves of the most susceptible apple trees. A typical example of the results is shown in plate 91, figs. 4 and 5. The twig in fig. 5 was unsprayed, while the twig in fig. 6, was sprayed; both were inoculated at the same time and under the same conditions. It will be observed that many lesions developed on the unsprayed leaves while no infection developed on the sprayed ones. Spray experiments were repeated many times during the summer and the results were consistent. Data on these experiments are presented in table XI. These data indicate that under experimental conditions colloidal sulfur has been entirely satisfactory in controlling *G. Juniperi-virginianae* on apple trees. Much encouragement is offered in regard to the employment of this spray material on a practical scale in apple orchards. It is my conviction that spray problems arising in practical control work can be overcome. The cost of colloidal sulfur does not exceed that of good spray products. Its control value and adhesiveness have been shown to leave little that is desired and it seems not to be injurious to either the leaves or fruit.

The following data also favor further investigations of colloidal sulfur as a practical orchard spray material. It has been shown by other workers that the spores of the apple scab organism, *Venturia inaequalis* (Cke.) Wint., are distributed during early spring rains. The distribution of these spores usually coincides with that of basidiospores of *G. Juniperi-virginianae*. It has also been shown that sulfur-containing fungicides will control apple scab. Therefore, it seems highly desirable that joint control of these two organisms by means of colloidal sulfur be thoroughly investigated. A program for this purpose is now in progress.

X. RECOMMENDATIONS

With the advantage of additional information now at hand it seems that both apple trees and red cedars may be grown in close proximity and at the same time practically free from *Gymnosporangium* rusts. Certain precautions, however, will greatly aid in the furtherance of such a scheme. The aecial hosts of the cedar-apple rust fungus are now known to be all of the North American species of the genus *Malus* and *M. sylvestris* of Europe. *Malus baccata* and *M. floribunda* have also been reported as susceptible. For practical purposes, those hosts on which spermogonia were developed (and these in small numbers) may be considered as immune since they cannot reproduce the rust. We have, therefore, a wide range of rust-free species and varieties from which to choose. Many of these vie with native apples in their beauty and adaptability as ornamental trees. Most of these have brightly colored fruits also, in contrast to the plain green of native species. All of the foreign species and varieties given in this study are hardy in the Arnold Arboretum. So far as I am aware no serious disease is liable to cause especial trouble to them. If orchard apples are desired in regions where red cedars are common, helpful information regarding the relative susceptibility of some 300 varieties will appear shortly in another publication. The *Juniperus* hosts of the cedar-apple rust fungus are the native *J. virginiana, J. horizontalis* and *J. scopulorum* and several varieties of each (see page 175). All other native species and all of the foreign ones have thus far proved to be immune. Several of the immune species and varieties bear a close resemblance to our native susceptible ones and these may be employed with satisfactory results. If, however, susceptible apples and red cedars are desired on adjacent plots, each may be effectively protected from the contagion by a screen of taller non-susceptible trees.

While planting programs are very effective in controlling this rust, eradication measures even on a limited scale may also prove very effec-

tive. Wild or scrubby apple trees as well as red cedars may be the source of inoculum infecting more prized specimens. As a control measure it is very desirable that such weed trees be removed. Cases have been known where a single scrub apple tree was for many seasons the source of inoculum causing a great deal of damage to a large grove of ornamental cedars.

Pruning out galls from cedar trees is generally not effective. Too many, especially of the smaller ones, are likely to be missed; moreover, to be effective they would have to be removed throughout a very wide area. Of course, under exceptional conditions removal of galls

TABLE XI.

RESULTS OF SPRAY EXPERIMENTS WITH LINCO COLLOIDAL SULFUR ½% PLUS CALCIUM CASIENATE ¼% DURING THE SUMMER OF 1933, ON M. IOENSIS PLENA

Date of inoculation	Experiment no.	Results on sprayed branches	Experiment no.	Results on unsprayed branches	Remarks
June 12	1	*0	3	*3	Spray applied June 10.
	2	0	4	3	
13	5	0	7	3	Heavy rain June 12, P. M.
	6	2	8	3	
14	11	0	9	3	
	12	0	10	3	
15	13	0	15	2	
	14	0	16	3	
16	17	0	19	3	Showers
	18	0	20	3	
17	21	0	23	3	Showers
	22	0	24	2	
18	25	1	27	3	Rain, A. M.
	26	2	28	3	
19	33	3	35	2	
	34	2	36	3	
20	--	-	--	-	
21	53	3	49	3	
	54	died	50	3	
22	57	1	61	3	
	58	2	62	3	
23	65	2	67	3	
	66	3	68	2	
24	--	-	--	-	
25	84	0	81	3	Spray applied on another tree June 25.
	84	0	82	3	
26	87	0	85	3	
	88	0	86	3	
27	93	1	95	3	
	94	0	96	3	
28	100	0	102	1	
	101	1	103	2	
29	109	0	111	2	Rain
	110	0	112	2	
30	113	0	115	2	
	114	0	116	3	

July 1.	125	0	127	1	
	126	lost	128	lost	
2	133	1	135	3	Rain
	134	0	136	3	
3	143	0	145	3	
	144	0	146	3	
4	155	1	153	3	Rain
	156	2	154	3	
5	---	-	---	-	Heavy rain
6	163	2	165	3	
	164	2	166	3	
7	173	3	175	3	
	174	3	176	3	
8	183	3	185	3	
	184	1	186	3	
9	195	0	197	3	Spray applied on another tree July 9, A. M. Showers July 9, P. M. Rain July 10.
	196	0	198	3	
10	201	0	203	3	
	202	0	204	3	
11	207	0	209	3	
	208	0	210	3	
12	213	0	215	3	
	214	1	216	3	
13	220	0	218	3	
	221	0	219	3	
14	225	0	227	3	
	226	1	228	3	
9	193	0	Controls as in the foregoing for July 9-14.		Spray applied to another portion of tree; no cal. cas. used. Remarks as in the foregoing for July 9-14
	194	0			
10	199	0			
	200	0			
11	205	0			
	206	0			
12	215	0			
	216	0			
13	221	0			
	222	0			
14	223	0			
	224	0			

*Refers to the amount of infection as follows:

0 — none
1 — slight
2 — moderate
3 — heavy

may be practicable. If in small isolated groups of cedars a few scattered galls have developed, every one of these could be removed before the buds of susceptible apple trees have begun to open, and good protection would result.

Fungicidal control of the rust on apple trees now gives promise of practicability. It has proved successful in my experimentation under controlled inoculation by using Linco colloidal sulfur at ½% strength. Tests under natural conditions are warranted. The time of application of the fungicide is very important and should coincide with the times of discharge of the basidiospores while the leaves are within their period

of susceptibility. The following spray schedule should be closely followed for the protection of orchard apples:

First application—Before the first expected rains after the leaf buds have opened. This will be about the first of May in Massachusetts and under certain conditions may coincide with the second application.

Second application—After the cluster buds have separated but before the petals have expanded. This is the "pink spray" of the apple scab schedule.

Third application—When the petals are about two-thirds off. This is the "calyx spray" of the apple scab schedule.

Fourth application—Ten days to two weeks later. Shorter intervals may be necessary if the weather is rainy. Colloidal sulfur will remain effective after two heavy or three moderate rains.

Fifth application—Need only be applied if the telia are still present on cedar trees and should occur ten days to two weeks later than the fourth application.

The foregoing spray schedule is based on stages of development of the flowers and applies particularly to orchard apples. The native ornamental apples, however, develop their foliage to a much greater extent than do orchard apples before flowers appear on the former. Thus certain modifications of the schedule are called for. The directions for the first application will apply to all trees. On the native ornamental apples the second application should be given from four to seven days after the first application. The third application seven to ten days after the second and the fourth and fifth applications in ten days to two week intervals. Variations in this schedule will be due to growing conditions and to rains. It must be borne in mind that the leaves should be well covered with the fungicide before rains. Linco colloidal sulfur will adhere and remain effective through about two heavy rains or three moderate ones. Thus, more frequent applications will be required if rains are abundant. The spray schedules as outlined above coincide with that generally recommended for the control of apple scab and this organism will be simultaneously controlled by the use of Linco colloidal sulfur. To control feeding insects, four pounds of arsenate of lead should be added to each one hundred gallons of the spray mixture.

Fungicidal control measures for application to red cedar cannot as yet be outlined with the same explicitness. The reason for this lies in the circumstance that it remains yet to be determined just when infection takes place. Since infection results from the spores discharged from the lesions on apple trees and some of them, though the percentage is very small, are immediately viable, it follows that protection should be afforded red cedars when their discharge begins. In Massachusetts this is about the first of July. The red cedars should, therefore, have a protective spray cover throughout July. It is possible that spores discharged later in the season may also cause infection. In such a case the spraying would have to be repeated in August and possibly September. My own tests are not sufficiently advanced to give the desired answer. A colloidal sulfur, such as Linco (½% strength) is advised.

XI. SUMMARY

1. Inoculations and examinations for infection were made on 108 species of 11 genera of plants in the Arnold Arboretum with *Gymnosporangium Juniperi-virginianae* from Massachusetts. The genera were *Amelanchier, Comptonia, Crataegomespilus, Cydonia, Malus, Myrica, Photinia, Pyrus, Sorbaronia, Sorbopyrus* and *Sorbus*. In addition field observations were made on 942 species of *Crataegus*.

2. The results of the inoculation experiments show that:

(a) All of the species and varieties (16 in number) of the section Chloromeles of the genus *Malus* and two other species, namely, *M. fusca* and *M. sylvestris*, produced aecia. The hosts showed differences in their degree of susceptibility to the fungus.

(b) Twelve species and varieties found in other sections of the genus produced spermogonia only. The infection spots were always few and the spermogonia were very irregular both in their time and in their manner of development.

(c) Other species and varieties of *Malus* (47 in number) and all other species tested or observed were found to be immune.

(d) The hosts on which aecia were produced were found to be susceptible for various periods of time. The most susceptible hosts could be infected throughout the greater part of the growing season. The less susceptible ones could be infected for progressively shorter periods down to about two weeks.

3. Examination of the genus *Juniperus* in the Arnold Arboretum showed that *J. virginiana* and twelve of its varieties, *J. scopulorum* and

two of its varieties, *J. horizontalis* and two of its varieties were susceptible to *G. Juniperi-virginianae*. Fifty-two species and varieties were immune.

4. The morphological and histological symptomatology of the disease on *Malus* spp. showed that the disease was most severe on the more susceptible hosts and less severe on the more resistant ones. The forced growth of infected buds, a phenomenon which seems to be confined to species and varieties of wild apples, is herein described for the first time. The geographical distribution of the pomaceous hosts, with one exception (*M. sylvestris* of Europe), and of the *Juniperus* hosts was confined to North America. The disease was found throughout the coinciding ranges of the hosts in the section Chloromeles and *J. virginiana* in eastern North America. The disease was not found within the range of *J. scopulorum* or *M. fusca* in western North America.

5. The life history of the aecial phase of the organism showed marked differences in the development of the mycelium and the fructifications on hosts of various degrees of susceptibility. The fungus developed most luxuriantly on the most susceptible hosts and less so on the more resistant ones.

6. To the life history of the telial phase little has been added; however, it was shown that a zone of fresh teliospores is produced by the telium after each of six or seven consecutive rains in the spring.

7. The possibility of biological strains of the fungus was investigated by employing telial material from eight states, namely, Alabama, Kentucky, Massachusetts, Michigan, Missouri, Nebraska, New York and West Virginia. The results showed that biological strains of this rust were present.

8. Several factors are discussed with respect to their influences on susceptibility, resistance, immunity and control on apple trees as well as red cedars.

9. Eleven states in eastern North America reported that they have either a cedar eradication law or a general plant pest law under the protection of which attempts have been made to eradicate red cedars from around productive orchards as a means of controlling the cedar-apple rust. Most of these states no longer enforce cedar eradication.

10. Several fungicides have been examined with respect to their value in controlling *G. Juniperi-virginianae*. Of these, a form of colloidal sulfur has given especially promising results in experimental tests to control the fungus on apple trees.

11. Recommendations have been discussed with respect to control measures by means of (1) selective plantings, (2) eradication of wild or scrubby apple and red cedar trees and (3) fungicides applied to apple trees in the spring and to red cedars in the summer and fall.

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EXPLANATION OF PLATES

Plate 91

Fig. 1. Spermogonia of *Gymnosporangium Juniperi-virginianae* on a mature leaf of *Malus glabrata,* a moderately susceptible species. The spermogonia, though numerous, are in small groups.

Fig. 2. Spermogonia on a young leaf of *M. Soulardi,* a very susceptible species. Large groups of spermogonia are characteristic of very susceptible species of *Malus.*

Fig. 3. Spermogonia along the midrib of *M. coronaria Charlottae.* The infection spots are fully mature and the yellowish-red peripheral zone is clearly marked.

Fig. 4. Fully mature infection spots on the very susceptible *M. ioensis plena,* showing their large size and the yellowish-red peripheral zone.

Fig. 5. Numerous infection spots on fully mature leaves of *M. ioensis plena.* Note that on the youngest leaves infection spots are larger and more numerous than the older leaves. This is a photograph of an unsprayed control branch inoculated July 20, 1933. Compare with figure 6.

Fig. 6. Branch of *M. ioensis plena* sprayed with Linco colloidal sulfur ½% plus calcium casienate ¼% and inoculated at the same time and under the same conditions as the branch in figure 5. Note that on this branch no infection spots were produced.

Fig. 7. Enlarged view of spermogonia on a leaf of an orchard apple. (After Giddings and Berg 1918.)

Plate 92

Fig. 1. Developing spermogonium on *M. ioensis plena* 8 days after inoculating. The buffer cells are rapidly expanding and push the epidermis upward.

Fig. 2. Developing spermogonium on the same leaf as fig. 1. The buffer cells are almost completely disintegrated and the spermatiophores are beginning to constrict spermatia. Figs. 1 and 2 ×400.

Fig. 3. Fully mature spermogonia on the leaf of *M. platycarpa.* ×70.

Fig. 4. Microscopic section of the whole infected area of *M. prunifolia.* ×70. The abortive spermogonium and limited infection area are typical of those host species on which only spermogonia develop.

Fig. 5. Diagram to show the location of measurements for spermogonia. h = height; w = width; d = depth to which the spermogonium is sunken beneath the epidermis.

Plate 93

Fig. 1. Infection cushions on a leaf of the very susceptible *M. coronaria Charlottae.* Large aecial cushions are typical of very susceptible hosts. Collected September 6, 1933. Nat. size.

Fig. 2. Infection cushions on a leaf of the moderately susceptible *M. platycarpa.* Aecial cushions of this size are typical of moderately susceptible hosts. Collected September 6, 1933. Nat. size.

Fig. 3. Infection spots on a leaf of the very resistant *M. fusca.* Collected September 6, 1933. On this date only one infection spot near the tip of the leaf remained alive, all others had died, and

with them a portion of the leaf tissues. Small aecial cushions and dead infection spots after September 1 are characteristic of resistant species. Nat. size.

Fig. 4. Enlargement of an aecial cushion on a leaf of *M. ioensis plena*. The concentric arrangement of the aecia is characteristic of very susceptible species. ×10.

Fig. 5. Enlargement of aecia on the fruit of an orchard apple. On fruits, aecia have no regular arrangement. ×10.

Fig. 6. Aecia on the calyx end of a fruit of *M. Soulardi*. Nat. size.

Fig. 7. Aecia on the pedicel of a fruit of *M. ioensis plena*. Nat. size.

Fig. 8. Aecia on one side of a fruit of *M. ioensis plena*. Nat. size.

Fig. 9. Aecia all over a fruit of *M. ioensis plena*. Nat. size.

Plate 94

Fig. 1. Photomicrograph at the border of an infection cushion on a leaf of *M. ioensis plena*. ×20. This shows clearly that the mesophyll is very greatly enlarged while the palisade tissue is quite unchanged morphologically. Compare the hypertrophy on this native species with that of a foreign species shown in plate 92, fig. 4. They are of about the same age. The latter figure is ×70 while this one is ×20.

Fig. 2. Young aecium on a leaf of *M. platycarpa*. A large number of apical peridial cells are present, but only a few aeciospores have been formed.

Fig. 3. Aecium of *G. Juniperi-virginianae* from *M. platycarpa* at a somewhat more mature stage. Numerous aeciospores and lateral peridial cells have developed.

Fig. 4. Diagrammatic drawing of spermogonia and aecia in several developmental stages. After Reed and Crabill (1915).

Fig. 5. Outline drawings of several aeciospores of *G. Juniperi-virginianae*.

Fig. 6. Drawings of peridial cells of *G. Juniperi-virginianae*.

Fig. 7. Haustoria of *G. Juniperi-virginianae* in the leaf and fruit tissues.

Plate 95

Fig. 1. Forced growth of an infected bud of *M. Soulardi*, harvested September 3, 1932. Mature aecia are present on the base of the bud and spermogonia on the petiole of the outermost leaf.

Fig. 2. Forced growth of an infected bud of *M. bracteata*, harvested September 15, 1932. Spermogonia are present on blades of the youngest leaves, and aecia are in progressive stages of development on the midribs of the older leaves.

Fig. 3. Forced growth of an infected bud of *M. ioensis plena*. Spermogonia are present over all of the upper surfaces of the misshapen leaves. Note the forced growth of a lateral bud at the base of the infected tissues of the twig.

Fig. 4. Shows aecia scattered irregularly over the lower surface of a leaf on the same twig as in fig. 3.

Fig. 5. A row of nursery plants of *M. ioensis plena* every twig of which was attacked and the plants were killed outright. It will be noted that the killed plants are between rows of a foreign species, *M. floribunda* which are in excellent health. Next to these on the right is a row of red cedars infected with *G. Juniperi-virginianae*.

Fig. 6. Forced growth of a lateral bud of *M. bracteata*. Compare with the normal bud near the base of the infected tissues.
Fig. 7. Winter aspect of a forced grown bud of *M. angustifolia*. The leaves of forced buds usually remain attached all winter and the portion of the twig beyond the bud is usually killed.

Plate 96

Fig. 1. A red cedar tree heavily infected with *G. Juniperi-virginianae*.
Fig. 2. A branch from the tree in figure 1 showing galls of various sizes.
Fig. 3. Average-sized galls as seen in early March.
Fig. 4. First appearance of telia of *G. Juniperi-virginianae* after a rain in late March or early April.
Fig. 5. Telia as seen after an additional rain.
Fig. 6. Telia as seen after two rains.
Fig. 7. Telia fully expanded. These are typical of the rust during spring rains.
Fig. 8. Telia at the end of the season of sporulation.

Plate 97

Fig. 1. Galls of *G. Juniperi-virginianae* in winter condition on red cedars of very poor health. Note the convoluted, shrunken appearance of the galls.
Fig. 2. A gall that produced one crop of telia and continued growth from its base for another season.
Fig. 3. Stages in the development of galls on red cedars.
Fig. 4. Galls on subulate leaves of red cedars.
Fig. 5. These telia were sprayed shortly before a rain. Note that the sprayed portion of the telia gelatinized but slightly; the more expanded portion emerged during the rain.
Fig. 6. These telia were also sprayed shortly before a rain. Note that the tip gelatinized to a very limited extent, the more robust basal portions were added during two subsequent rains. A constriction in the swollen basal part of each telium lies between the additions made during the rains.
Fig. 7. A spore print of basidiospores of *G. Juniperi-virginianae*.

Plate 98

Fig. 1. Photomicrograph of a cross section of two depressions in a gall of *G. Juniperi-virginianae*. Early stages of the development of the telium are shown.
Fig. 2. Stages in the development of teliospores of *G. Juniperi-virginianae*.
Fig. 3. Outline drawings of teliospores of *G. Juniperi-virginianae*.
Fig. 4. Cross section of the telium of *G. Juniperi-virginianae*. It will be seen that teliospores are located chiefly on the periphery of the telium.
Fig. 5. Camera lucida drawings of haustoria of the telial phase in cells of the galls of *G. Juniperi-virginianae*.

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Fig 1 Fig 2 Fig 3.

Fig 4

Fig 5.

Fig 6.

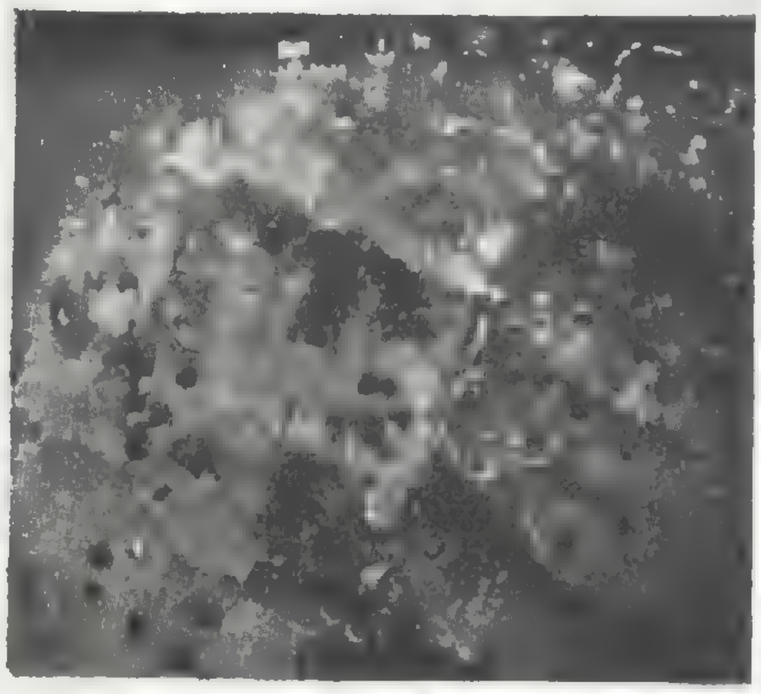
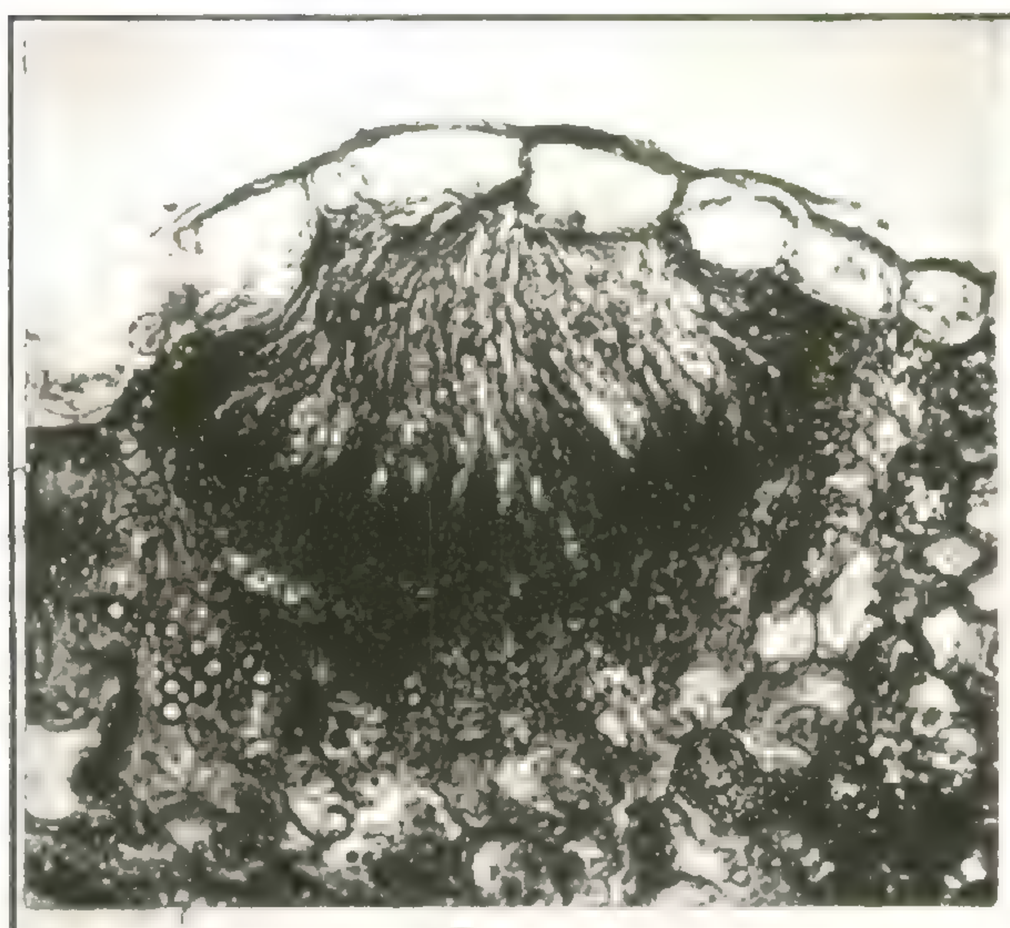


Fig. 7

Cedar-Apple Rust Fungus



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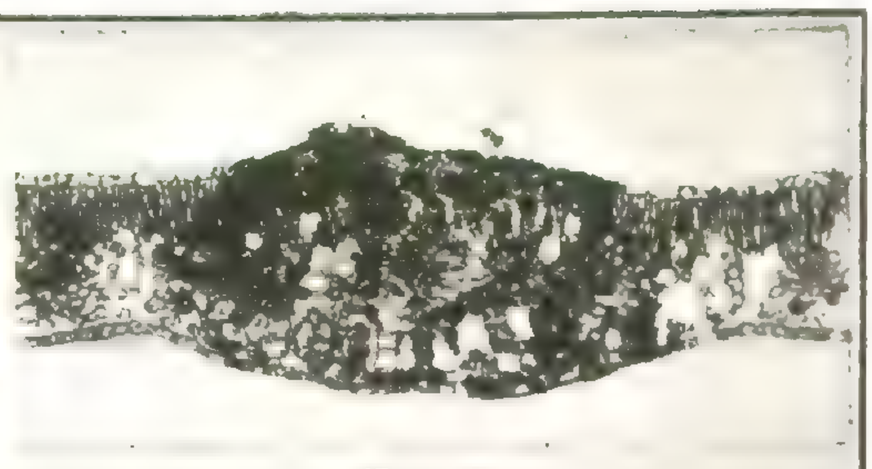

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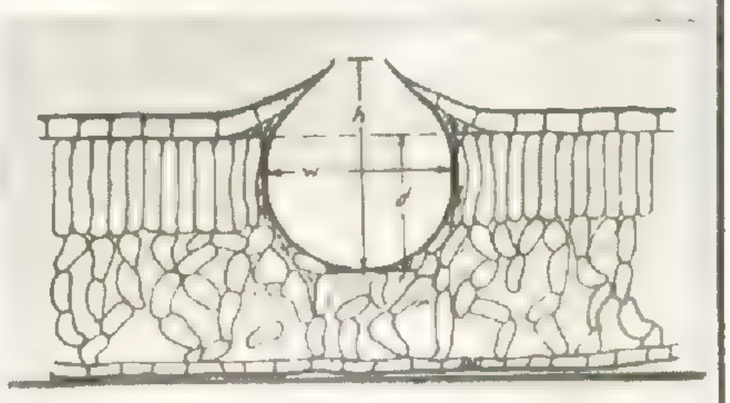

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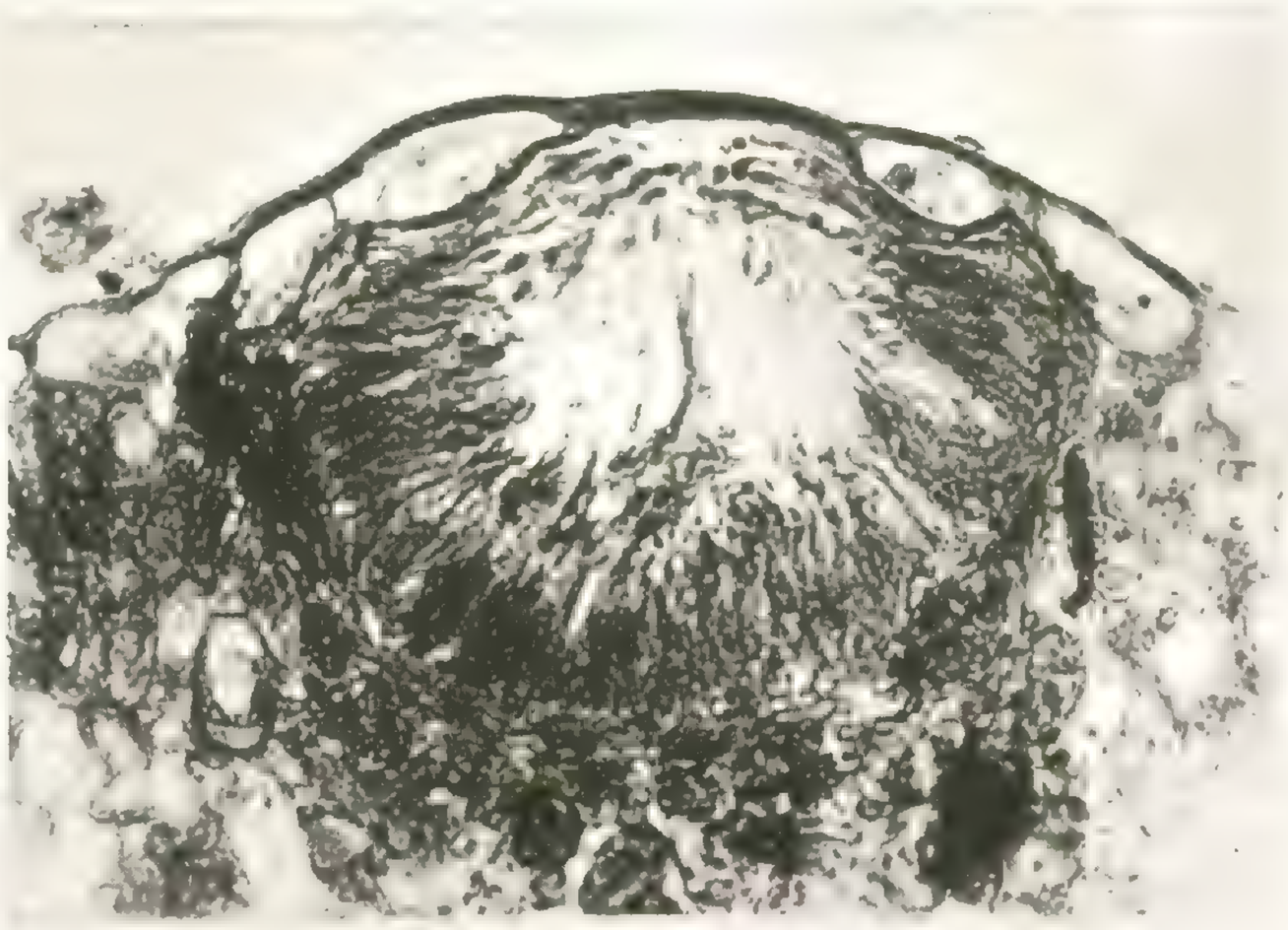

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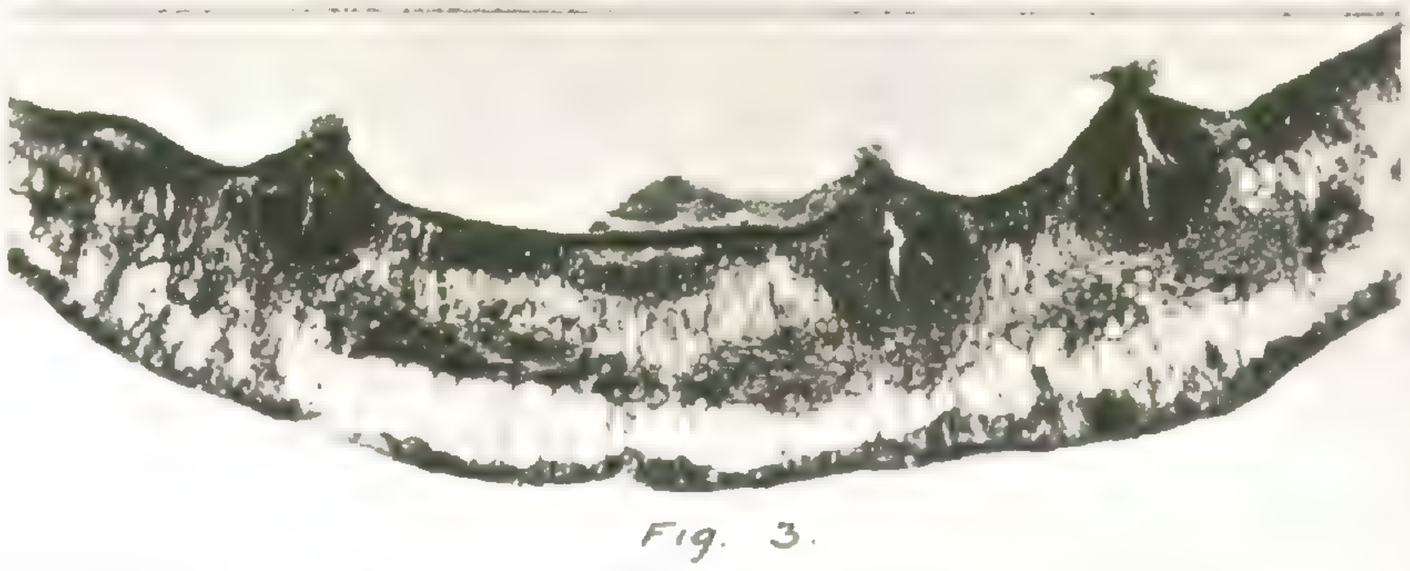
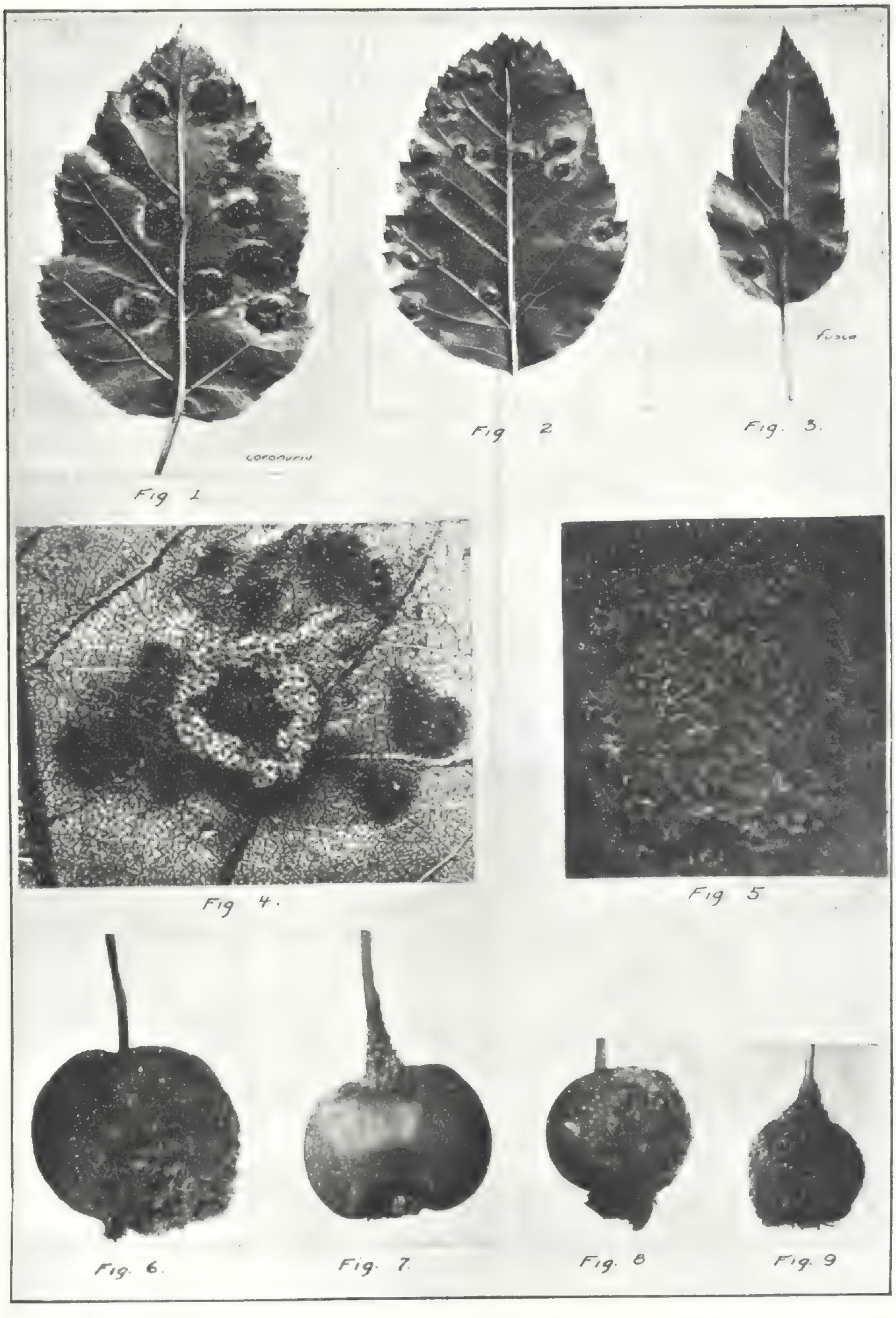
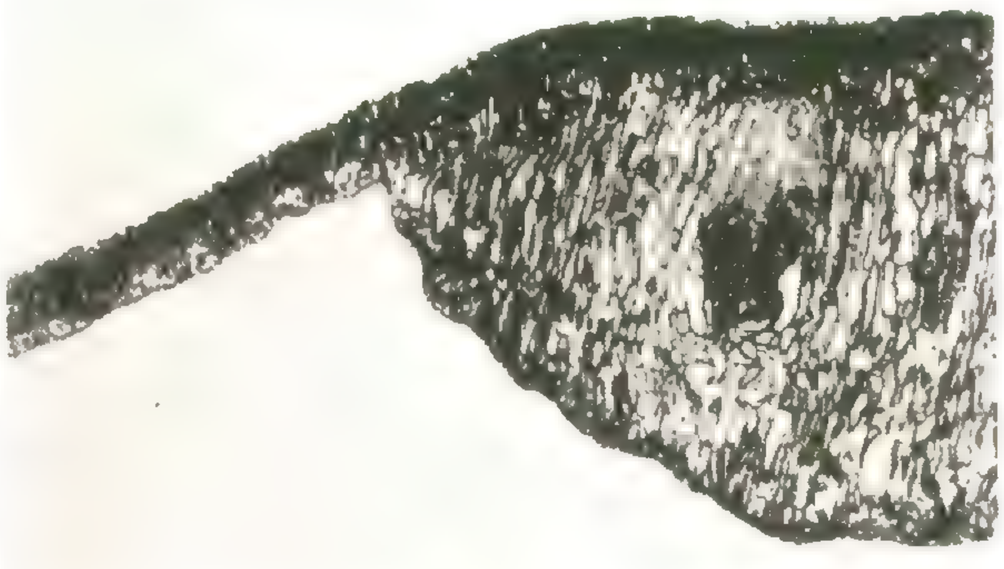


Fig. 3.

Cedar-Apple Rust Fungus



CEDAR-APPLE RUST FUNGUS



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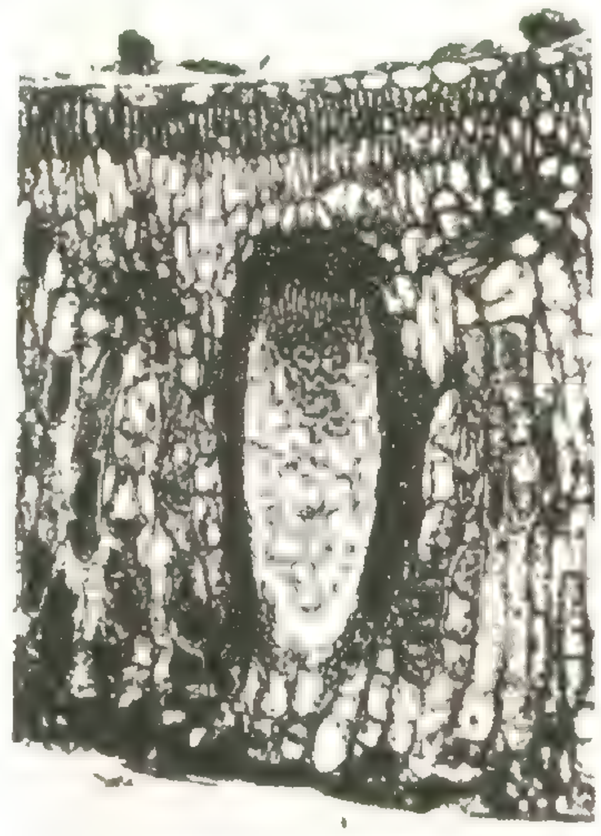

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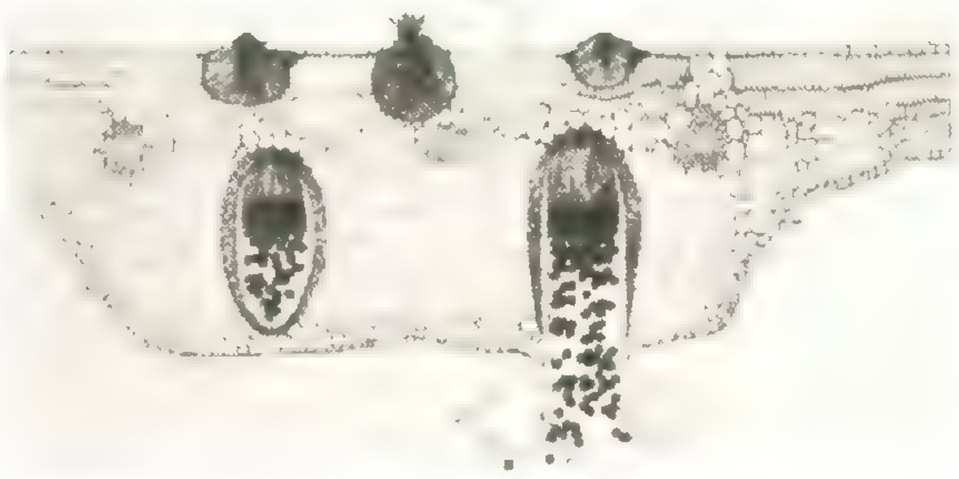

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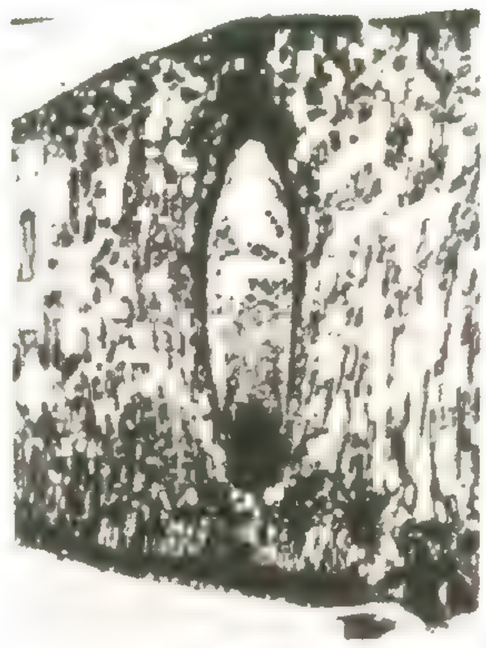

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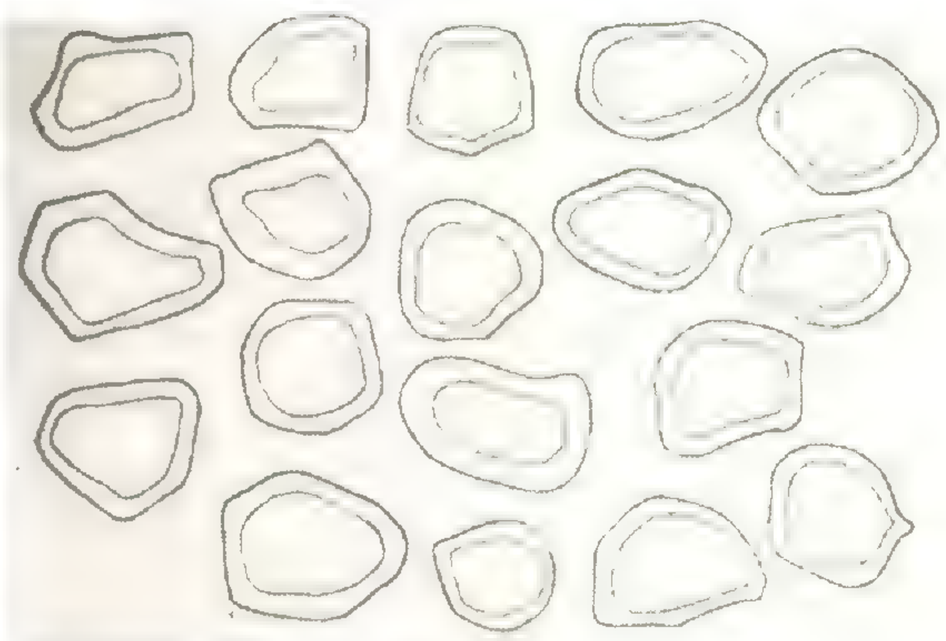

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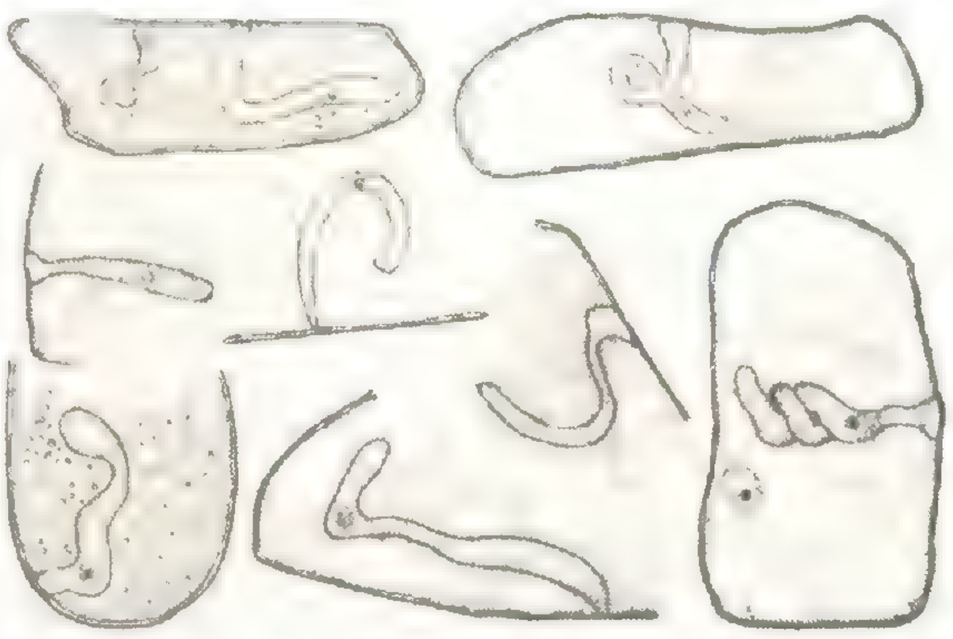

Fig 7

Cedar-Apple Rust Fungus

Fig. 1.

Fig. 2.

Fig 3

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Fig 5

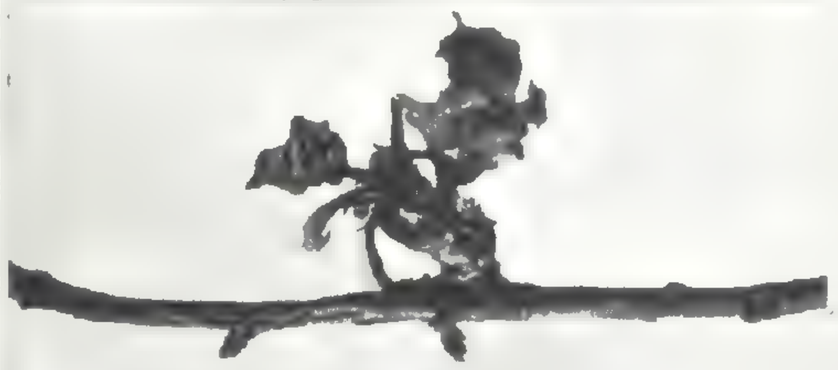

Fig. 7.

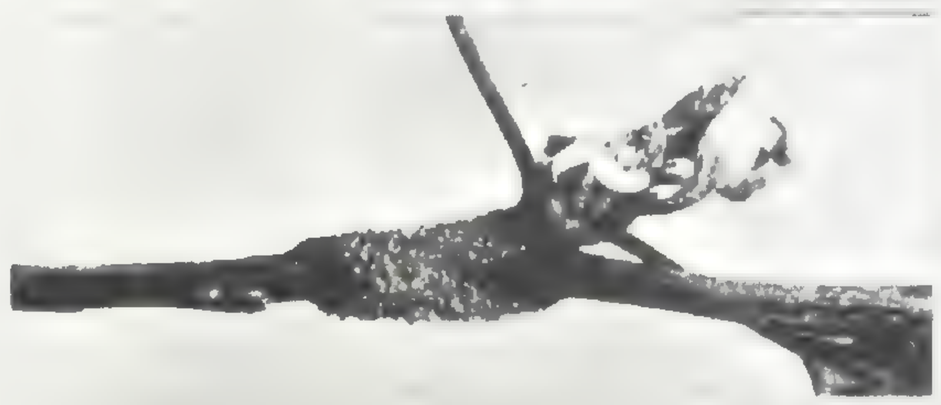

Fig. 6.

CEDAR-APPLE RUST FUNGUS

CEDAR-APPLE RUST FUNGUS

Fig. 1

Fig. 2.

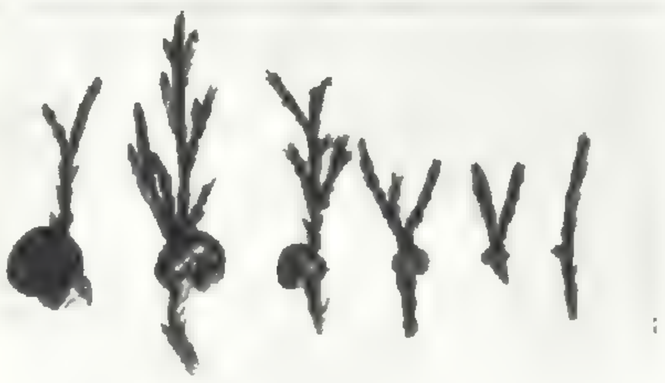

Fig. 3

Fig 4

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Fig. 6

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CEDAR-APPLE RUST FUNGUS

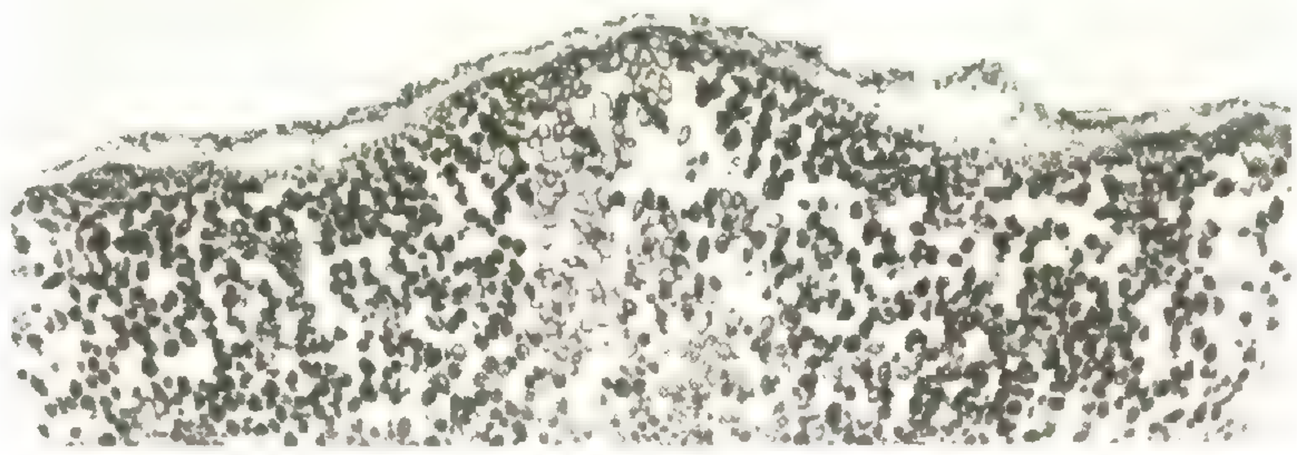
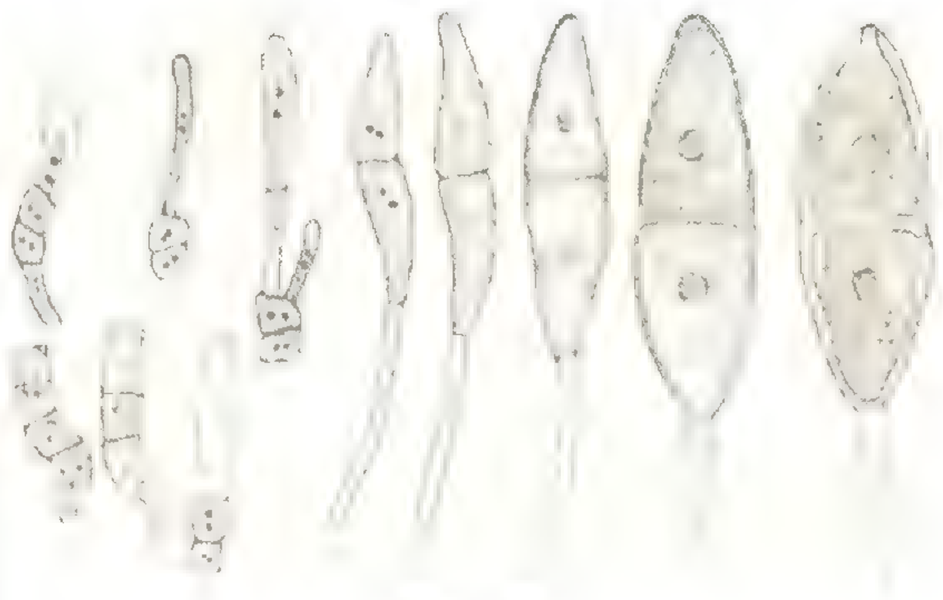


Fig 1



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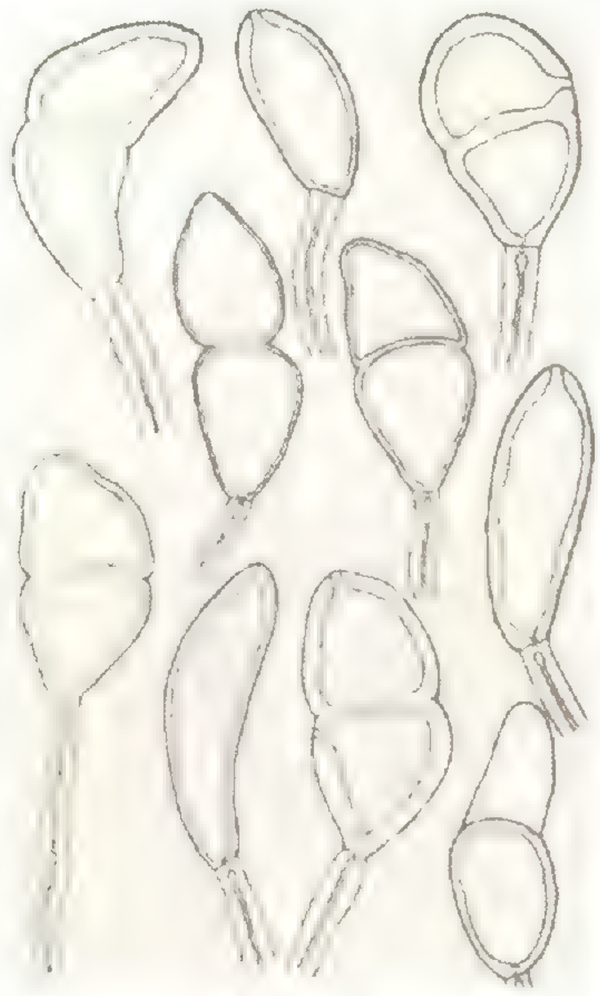
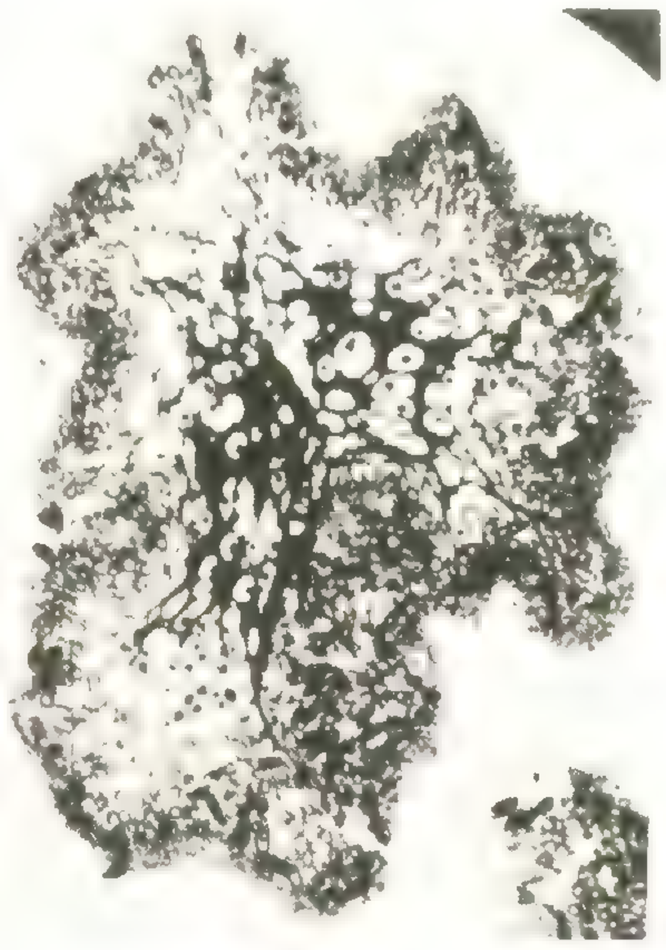


Fig 3



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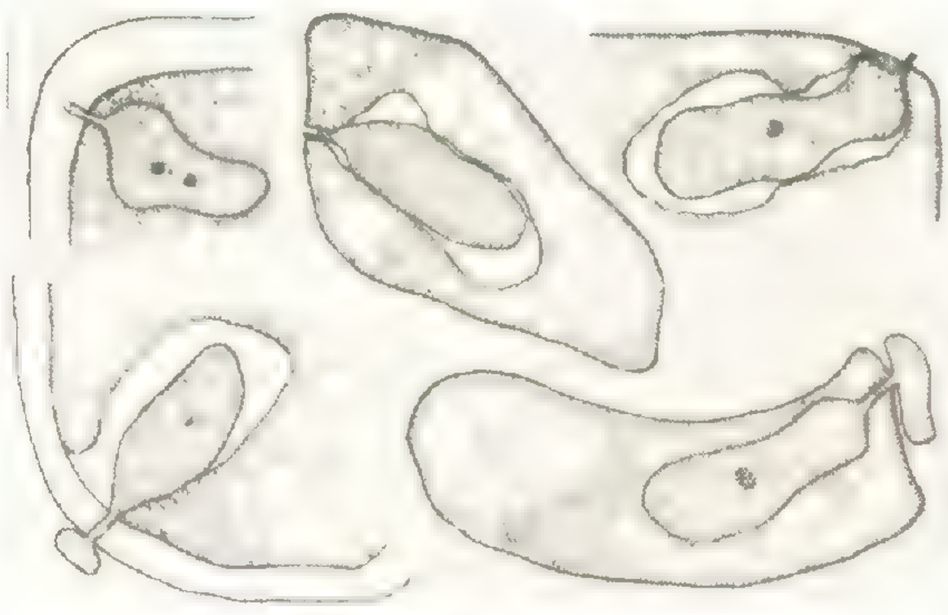


Fig. 5

Cedar-Apple Rust Fungus

THE CAMBIUM AND ITS DERIVATIVE TISSUES

NO. IX. STRUCTURAL VARIABILITY IN THE REDWOOD, SEQUOIA SEMPERVIRENS, AND ITS SIGNIFICANCE IN THE IDENTIFICATION OF FOSSIL WOODS

I. W. Bailey and Anna F. Faull

With one text figure and plates 99-106

INTRODUCTION

Systems of classifying the woods of conifers and dicotyledons have developed largely through trial and error, and in many cases do not provide a reliable basis for the identification of fossilized specimens. This is due to the fact that comparatively little is known concerning the limits of variability of the diagnostic criteria used in the construction of keys.

In the seventh paper of this series (Bailey, 3) it was shown that a number of the so-called transitional Mesozoic Coniferæ fall within the range of variability of living representatives of the Pinaceæ-Abietoideæ. If *Protocedroxylon, Planoxylon, Protopiceoxylon,* etc., are to be classified as Protopinaceæ or Araucariopityeæ, then so should certain specimens of the wood of *Cedrus, Keteleeria,* and other extant genera. Such paradoxical situations can not be fully clarified until large collections of authentic specimens are assembled, not only from different genera, species, and geographical races, but also from different parts of the tree and from trees growing under different environmental conditions.

In choosing a species for an investigation of the range of variability of anatomical characters, it seemed advisable to select the redwood, *Sequoia sempervirens* Endl. This tree is of unusual interest not only because of its large size and longevity, but also because it belongs to a genus which has been, and still is, the subject of frequent discussion in paleobotanical literature.

MATERIAL

Most of the material from mature stems of large diameter was collected by Professor A. E. Douglass in connection with his investigation of tree rings. Entire cross sections were secured from different heights in the tree and from trees growing in different parts of the extensive range of the redwood. Small specimens suitable for anatomical study were removed along specific radii of these huge cross sections. Specimens from roots, branches, and stems, of both seedling-

trees and sprout-trees, were collected by the senior author in Mendocino and Monterey counties. Additional material was obtained through the kind assistance of Mr. Frank Poulter, Professor Emanuel Fritz of the University of California, Mr. H. L. Person of the California Forest Experiment Station, Dr. D. T. MacDougal and Mr. F. W. Haasis of the Carnegie Institution, and others.

GROWTH LAYERS

The growth layers of the redwood, as seen in transverse sections, vary considerably in width, in the ratio of latewood to earlywood, and in the abruptness of the transitions between thin-walled and thick-walled tracheids, *Figs. 1-13*. In young trees growing under favorable environmental conditions, the growth layers of the stem commonly attain a width of from 4-10 millimeters, *Fig. 11*. During the subsequent development of the trees, the rings tend to become narrower and narrower, *Figs. 3-5*, and may actually be reduced at times to the theoretical minimum of two tracheids, i.e., one thin-walled cell and one thick-walled cell, (a) in *Fig. 5*. Such sequences of growth layers of decreasing width, although of not infrequent occurrence, are by no means a characteristic feature of all redwoods. The species grows naturally in forests of the "selection type," and a large proportion of the trees originate as sprouts which develop in deep shade and are forced to grow for a varying period of years in a more or less suppressed condition. Thus, many of the trees in virgin forests have relatively narrow rings throughout the stem, or alternating zones of narrow and wide rings; for even old suppressed trees may form wide rings, *Fig. 13*, when released from the competition of their dominating neighbors (Fritz, 12), or in response to specific tropisms, *Fig. 6*. Excentric arcs of abnormally wide growth layers, false rings, *Fig. 12*, incomplete rings (Fritz and Averell, 11), and burly or curly structures are of very common occurrence. As stated by Fisher (10), "the tree's vitality is so great, it endures so many vicissitudes, and suffers from so many accidents in the centuries of its existence, that the grain of its wood becomes uneven in proportion as its life has been eventful." The growth layers of branches and roots, *Figs. 7-10*, tend to be narrower than those of stems of comparable ages. It is evident, accordingly, that in the redwood as in many other Coniferæ, width of annual ring is a fluctuating character which varies within rather wide limits, not only within different parts of a single tree, but also within homologous portions of trees having different developmental histories.

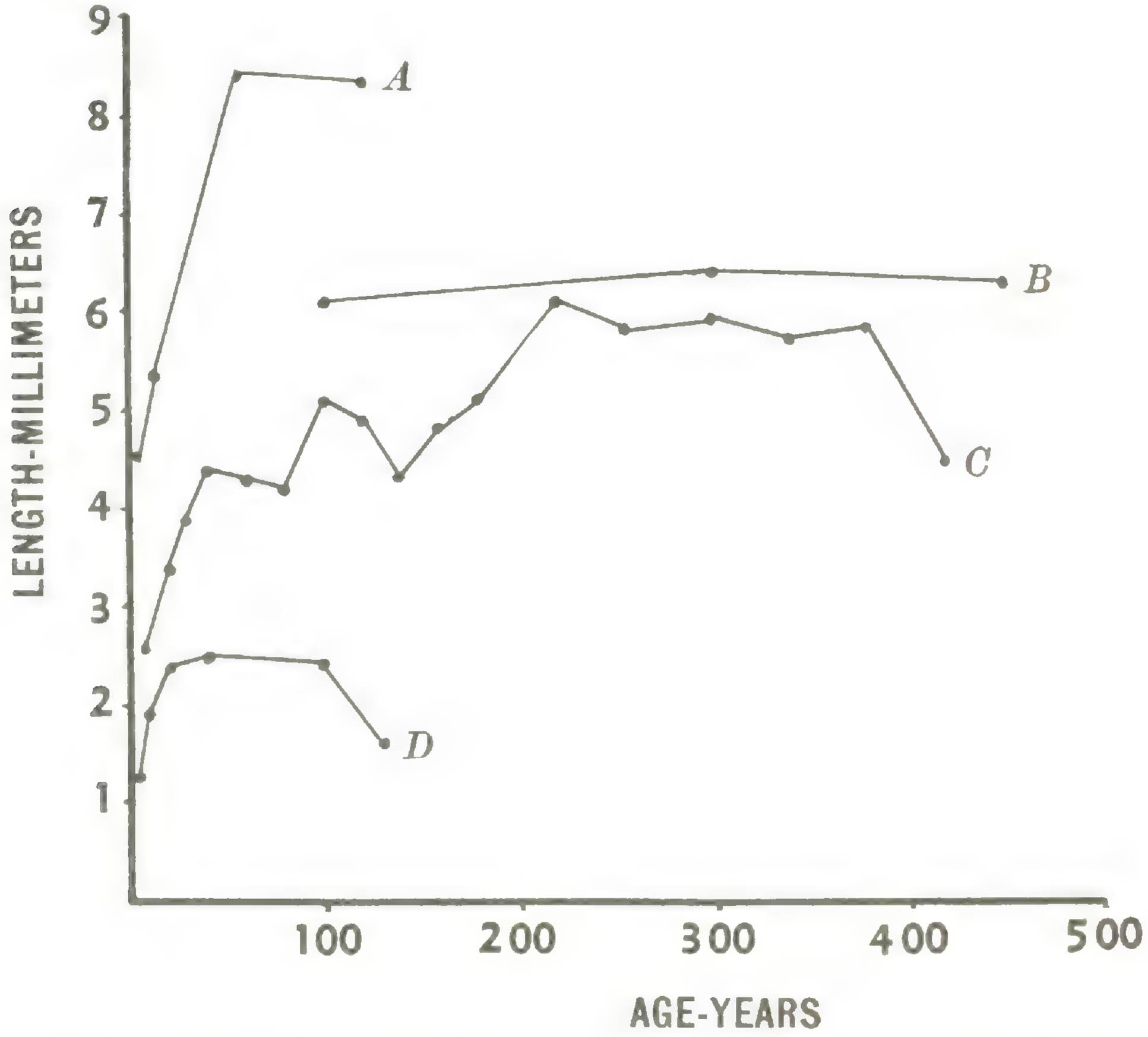
In narrow rings from the peripheral portions of old stems, roots, and branches, *Figs. 4, 5, 8,* and *10*, the ratio of latewood to earlywood is

low, 1:6 to 1:20, and the transitions between thin-walled and thick-walled tracheids are very abrupt; whereas in wide rings, *Figs. 3, 6,* and *13,* the ratio tends to be higher, 1:3 to 4:7, and the transitions may be either gradual, *Fig. 13,* or abrupt, *Figs. 3* and *6*. In the inner rings of stems and branches, the ratio of latewood to earlywood tends to be lower in the wider rings, *Figs. 1, 2, 7, 11,* and *12,* and the transitions between the two types of tracheids to be so gradual that it is difficult to determine with certainty just where the earlywood leaves off and the latewood begins. Paul (23) and Luxford and Markwardt (22) have shown that in the case of second-growth redwood, specific gravity and strength values are lower in open grown trees with large crowns and wide rings than in trees of densely stocked stands with small crowns and narrower rings, the differences being due, in ultimate analysis, to variations in the ratio of latewood to earlywood. It should be emphasized, however, that there are numerous exceptions to these general tendencies, particularly in "compression wood" (Hartig, 16), and in tissues growing under abnormal conditions. For example, *Fig. 9* is a transverse section of "compression wood" from the under side of an old slowly growing branch. The narrow rings are composed entirely of thick-walled tracheids, and it is difficult to distinguish the limits of the individual growth layers.

TRACHEARY ELEMENTS

The size, form, and arrangement of the tracheids—of both earlywood and latewood—vary markedly in different parts of a single tree and in homologous parts of trees which have had different developmental histories. As shown by Sanio (27), Hartig (15), Shepard and Bailey (29), and subsequently by many others, the tracheids of Coniferæ are smaller in the inner than in the outer rings of the stem. This is due primarily to an increase in the length and tangential diameter of the cambial initials, particularly during the earlier years of the meristematic activity of the cambium (Hartig, 15; Bailey 1, 2). Thus, in passing from the pith outward through the xylem of old, straight-grained, symmetrical stems, the derivatives of the cambium become longer and wider until they eventually attain dimensions which remain more or less constant through succeding annual rings. The detailed investigations of Bailey and Tupper (4) indicate that in any particular radius of the stem, the size-on-age curve, or one or more portions of it, may deviate from the normal, owing to the effects of various modifying factors. For example, the distorted tissue formed subsequent to injury, or in response to abnormal conditions of growth, commonly possesses shorter tracheids than normal tissue. Similarly, tissue formed in regions of the tree

where there are mechanical stresses, i.e., at the junction of stems and roots or branches, or in bent or deformed stems, tends to have smaller tracheids than normal, straight-grained tissue. Therefore, the largest tracheids usually occur in the "clear length" of tall trees or that central portion between the swollen base and the crown which is devoid of branches; whereas smaller tracheids are characteristic of suppressed branches and of the physiologically dwarfed stems of depauperate plants.



TEXT FIGURE 1. Graphs illustrating variations in length of tracheary elements in passing from the innermost to the outermost secondary xylem. (A) Root: 2½ inches in diameter and 120 years old. (B) Root: 12 inches in diameter and 450 years old. (C) Stem: 5 feet in diameter and 420 years old, at stump height. (D) Branch: 1¾ inches in diameter and 130 years old, from the crown of a huge old tree. Each point on the graphs represents an average of 100 measurements.

As indicated in *Text fig. 1*, the tracheary elements of the redwood fluctuate in length much as they do in other representatives of the Coniferæ, but the range of variability tends to be greater than in smaller

and shorter-lived species. In the material examined by us, the tracheids vary from less than a millimeter to more than a centimeter in length. The longest cells occur in roots, *Text fig. 1, A* and *B*, and the clear length of tall stems, whereas shorter cells are formed in branches, *Text fig. 1, D*, and in suppressed stems.

The tracheids of *Sequoia sempervirens* fluctuate from less than 10 μ to more than 100 μ in diameter. In radial strips from the clear lengths of huge mature trees, the average tangential diameter of the tracheids commonly varies from approximately 20 μ in the innermost rings to 60 μ in the outer growth layers, *Figs. 1, 4,* and *5*. In old suppressed branches, on the contrary, the differences in diameter, 18 to 24 μ, may be scarcely detectable, *Figs. 7-9*. In the roots of the Abietineæ, the widest tracheids frequently occur in close proximity to the primary elements; whereas in the redwood the tracheary cells commonly are smaller in the innermost rings, *Figs. 15* and *16*, but rapidly attain dimensions which are comparable with those of the tracheids of the outermost rings of old stems (compare *Figs. 3-5*, and *10*).

The form of the tracheids, as seen in transverse sections, varies from square or rectangular, *Figs. 2* and *5*, to asymmetrically pentagonal or hexagonal, *Figs. 4, 10,* and *16*, and in typical "compression wood" to oval or nearly circular, *Figs. 6* and *47*. Radially narrow rectangular forms are characteristic of the outermost tracheids of wide rings and of the entire latewood of such growth layers as those illustrated in *Figs. 4, 5, 8,* and *10*. Radially elongated forms are of common occurrence in large-celled earlywood of old stems and roots, *Figs. 4, 6, 10,* and *16*. Owing to variations in the size of tracheids and in the thickness of their walls, specific gravity is not a constant for either earlywood or latewood.

INTER-TRACHEARY PITTING

The more conspicuous variations in the size, form, number, and orientation of the bordered pits in the radial walls of the tracheids, *Figs. 20-30*, are more or less closely correlated with fluctuations in the size of these cells and in the thickness of their walls. In other words, the bordered pits tend to become larger and more numerous as the tracheids increase in radial diameter in an expanding stem or root (compare *Figs. 20* and *25, 26* and *30, 28* and *29*); but, within each growth layer, they decrease in size and number in passing from the larger thin-walled elements of the earlywood to the smaller thick-walled cells of the latewood. The pits commonly tend to be more numerous toward the overlapping ends of the tracheids and in those portions of the radial walls which are in contact with the terminal portions of

adjoining tracheids. Furthermore, the pits tend to be more numerous in relatively narrow rings than in unusually wide growth layers. Therefore, in studying variations in tracheary pitting, it is essential not only to compare homologous parts of the growth layers, but also equivalent areas of the walls of the tracheids.

The radially narrow tracheids of the latewood and the earlywood tracheids of the inner growth layers of stems and branches usually have a single row of small bordered pits; i.e., a single bordered pit is formed over each of the more or less conspicuous primary pit-fields, *Fig. 25*. On the contrary, the large earlywood tracheids of old stems and roots may form from 1-4 large bordered pits over each of the transversely elongated primary pit-fields, *Figs. 20-23*. Where the pits are approximated vertically, *Fig. 20*, the crassulæ[1] ("Bars of Sanio") are rodlike, and the primary walls have a scalariform appearance; where they are more widely spaced, *Figs. 21-23*, the crassulæ tend to be curved about the upper and lower margins of the oval primary pit-fields. "Forked," "split," or "fused" and very broad crassulæ, *Figs. 21* and *25*, are likewise of frequent occurrence.

Although the tracheary pitting of the redwood is commonly of the so-called opposite type, it readily passes over into typical alternating and closely crowded arrangements. When this change occurs, primary pit-fields and crassulæ are eliminated, *Figs. 27-29*, except in the case of such transitional or intermediate types of pitting as are illustrated in *Fig. 21*. In the redwood, as in *Cedrus* and other representatives of the Abietoideæ, the alternating orientation is of more frequent occurrence in roots than in stems; and, in the case of the aerial portions of the tree, in tracheids in close proximity to the primary wood and in the outer narrow rings of very old huge stems than in intervening tissue.

The individual bordered pits, which vary in diameter from 5-25 μ, may be circular, *Figs. 22, 23*, and *25*, oval or transversely elongated, *Fig. 30*, or flattened on one or more sides by close crowding, *Figs. 20, 21, 27*, and *29*. Many of them have conspicuously indented or notched contours, *Figs. 22, 23, 25*, and *26*. The pit apertures may be circular, oval, lenticular, or slitlike; their form and orientation fluctuating with variations in the physical structure (Zimmermann, 31) and thickness of the secondary walls of the tracheids.

When thin, transverse sections of normal tracheids are examined in polarized light with crossed nicols, the secondary walls are seen to con-

[1]In this paper, we have adopted the terminology proposed by the Committee on Nomenclature of the International Association of Wood Anatomists (6).

sist of three distinct layers, *Fig. 46*: (1) a thin, outer layer which transmits polarized light and is brilliant, (2) a thin, inner brilliant layer, and (3) an intervening layer of varying thickness which is dark or transmits less light than the inner and outer layers (Dippel, 7). The transmission of polarized light is closely correlated with the orientation of micellæ or chains of cellulose molecules. Where these are arranged parallel to the long axis of a tracheid, a layer appears dark in cross sections of the xylem; where they are oriented nearly at right angles, a layer is brilliant. The transmission varies at intervening angles. In other words, the micellæ of the thin inner and outer layers of the secondary wall tend to be oriented more nearly at right angles to the long axis of the cell, whereas those of the central layer are arranged either longitudinally or diagonally.

Variations in the thickness of the secondary wall are closely correlated with fluctuations in the width of the central layer, rather than of the inner and outer layers, *Fig. 46*. Where the central layer is relatively thin or inconspicuous, as, for example, in the large earlywood tracheids of old stems and roots, the pit apertures tend to be circular or transversely elongated; whereas in tracheids with thicker walls the apertures usually are lenticular or slitlike and are oriented either longitudinally or diagonally. The outlines of the apertures of a pit-pair may be superimposed or "crossed," the latter condition occurring where the orientation of lenticular or slitlike pits is diagonal. The secondary wall of the tracheids of "compression wood" differs from that of normal tracheids in having a wide inner layer, *Fig. 47*, which is coarsely and diagonally striated (Hartig, 16). This layer develops more or less numerous spirally arranged cracks during dehydration, and the apertures of the pits become extended far beyond the outlines of the borders.

The torus—i.e., the thicker central portion of the pit-membrane which stains intensely with Ruthenium Red or Haidenhain's Hæmatoxylin—varies markedly in size, form, and thickness. It may be absent, small and of irregular form, *Fig. 30*, or large, thick and disk-like, *Fig. 26*. Frequently it is conspicuously punctate, and the surrounding portion of the pit-membrane commonly tends to be more or less clearly striated or reticulated.

Bordered pits may develop in the tangential walls of the tracheids of both earlywood and latewood, particularly in the case of the narrower growth layers of old stems and roots. The tangential pits of the earlywood are larger, of sporadic distribution, and tend to have circular or oval apertures; whereas those of the latewood are smaller,

more numerous and uniformly distributed, and have lenticular or slit-like apertures. Crassulæ and primary pit-fields are absent in the tangential walls of the tracheids, but tori may be present in the bordered pits.

WOOD PARENCHYMA

The wood parenchyma of the redwood, as of many other Coniferæ, varies greatly in different parts of a single tree. It may be abundant and diffused throughout most of an annual ring, *Figs. 1, 7, 8,* and *11,* aggregated into more or less conspicuous zones, *Figs. 9* and *13,* confined to the latewood, *Fig. 2,* or much reduced in amount, *Figs. 4, 5, 6,* and *10.* Not infrequently it tends to be more abundantly developed in the inner than in the narrow outer rings of old stems and roots.

The individual strands of wood parenchyma fluctuate in length and in tangential diameter much as do the surrounding tracheary elements. This is due to the fact that both categories of cells are derived from the same fusiform initials, and therefore increase in size as the cambial initials become longer and wider. Minor differences in the length and cross-sectional area of parenchyma strands, as contrasted with tracheids, are due to differences in enlargement during tissue differentiation. The derivatives of the fusiform initials which divide transversely to form strands of wood parenchyma, do not elongate during differentiation of the xylem, whereas young tracheids may do so. The radial expansion of the parenchyma strands frequently tends to be less than that of the adjoining tracheids, but in the inner rings of roots the cross-sectional area of the parenchymatous elements may at times exceed that of the largest tracheids.

RAYS

Fisher (9), Essner (8), and Jaccard (18) have shown that rays vary in size and in number per unit area not only within different parts of a single tree but also within different parts of a single growth layer. In the redwood, as in the Coniferæ studied by Essner, the rays are smaller and more numerous, *Fig. 33,* in the innermost rings of stems and branches than in subsequently formed tissue, *Figs. 31, 32, 35-37.* This is due in part to an increase in height of the rays with concomitant ray-fusions, in part to an increase in the tangential diameter of the intervening tracheids, and in part to other factors. The height and width of the rays and the number of rays or ray cells per unit area are not constants, however, even in the outer growth layers of roots, branches, and stems, *Figs. 31, 32, 35-37.* The maximum height of the rays varies from a few cells to more than 75 cells, and the maximum

width from uniseriate to biseriate or triseriate and occasionally to multiseriate.

The individual ray cells fluctuate in size and form in different parts of a single tree and in homologous parts of different trees. The length, i.e., the radial dimension, of the ray cells varies from less than 35 μ to more than 500 μ; the depth, i.e., the vertical dimension, from less than 16 μ to more than 70 μ; and the width, i.e., the tangential dimension, from less than 9 μ to more than 40 μ. In general, the ray cells tend to be longer in earlywood than in latewood, in wide rings than in narrow ones, and in outer growth layers than in the innermost ones. Roots and the larger-celled growth layers of old stems tend to have broadly oval or "squarish" ray cells as seen in tangential sections, *Figs. 31, 36,* and *61;* whereas branches and the smaller-celled inner growth layers of stems commonly have narrower ray cells, *Figs. 32, 33, 35,* and *62,* in which the vertical dimension exceeds the tangential dimension. The ray cells, as seen in radial longitudinal sections of the xylem, may be uniformly rectangular or somewhat tapering in outline, with curved or diagonally oriented end walls. Furthermore, the marginal cells of the rays may be of approximately the same height as the central cells, or they may be much larger and provided with conspicuously curved outer walls.

PITS BETWEEN TRACHEIDS AND RAY CELLS

The ray cells of the redwood, as of the Taxodiaceæ, Araucariaceæ, Taxaceæ, Podocarpaceæ, Cupressaceæ, and Cephalotaxaceæ,[1] are provided with a more or less thickened primary wall, but do not form a true secondary wall such as is a characteristic feature of tracheary cells and of the rays of the Abietoideæ and most arborescent dicotyledons. This primary wall is derived directly from the ray initials of the cambium and is, in fact, a more or less modified cambial wall. As in the case of the ray initials, it is provided with more or less conspicuous primary pit-fields and plasmodesmata, i.e., sieve pitting, and tends to be conspicuously thickened at the angles of the cells where in contact with intercellular spaces, *Figs. 61,* and *62.* Simple pits and pits to intercellular spaces, which are characteristic features of the ray walls of the Abietoideæ, are entirely absent.

The presence of a true secondary wall in the rays of the Abietoideæ and its absence in the rays of the Taxodiaceæ, Cupressaceæ, etc., are of fundamental significance in any discussion of ray pitting. For

[1]Pilger's (25) nomenclature for the principal sub-groups of the Coniferæ is used throughout this paper.

example, there is at times a certain superficial resemblance between the end walls of the ray cells of *Juniperus* and those of *Cedrus*, *Abies*, or *Tsuga*. In *Juniperus* the investigator is concerned with deeply depressed primary pit-fields in primary walls, whereas in *Cedrus*, *Abies*, or *Tsuga* he is concerned with simple pits in secondary walls, i.e., entirely distinct morphological structures. In the case of pits in the "crossing field" or "tracheid field" of the rays of *Abies* or *Cedrus*, the investigator is dealing with half bordered pit-pairs; whereas in the rays of *Juniperus* or *Sequoia*, he is dealing with bordered pits which have no complementary simple pits on the ray side. The pit membranes are double structures formed by the wall of the ray and the adjacent primary wall of the tracheid, just as the tori and pit membranes of paired bordered pits are formed by the two adjacent primary walls of the tracheids.

The tracheary pits, which are visible through the crossing fields of the ray cells of the redwood, *Figs. 38-45*, vary in number from one to more than 20; in diameter, from less than 5 μ to more than 15 μ; in form, from circular or oval to asymmetrical; and in orientation from horizontal or vertical rows to diagonal or irregular groupings. The pit apertures, *Figs. 38-45*, may be slitlike, lenticular, or so much enlarged that the pit borders are more or less completely eliminated. Fusion of pit apertures, *Fig. 40*, or of both pit apertures and pit chambers, *Fig. 39*, are of not infrequent occurrence. Pit apertures may be oriented parallel to the long axis of the ray cells, *Fig. 38*, parallel to the long axis of the tracheids, *Fig. 45*, or in various diagonal positions, *Figs. 39-44*. As in the case of inter-tracheary pitting, variations in the orientation of the pit apertures are closely correlated with fluctuations in the thickness of the secondary wall of the tracheids and in the physical structure of its constituent layers.

The more conspicuous variations in the number and orientation of the pits within the outlines of a crossing field are correlated with fluctuations in the radial diameter of the tracheids and in the height of the ray cells. In other words, low ray cells in contact with narrow tracheids, *Figs. 39*, *41*, and *43*, tend to have fewer pits per crossing field than similar ray cells in contact with wider tracheids, *Figs. 38*, *40*, *42*, and *45*, or than high ray cells in contact with either narrow or wide tracheids, *Fig. 44*. Where the crossing field is much elongated radially, the pits tend to occur in horizontal rows, *Fig. 38;* but where it is vertically elongated, the pits usually are oriented in vertical rows, *Fig. 44*. Thus, in the outer growth layers of old stems and roots, the orientation of the pits shifts from horizontal to vertical in passing from the wide tracheids of the earlywood to the narrow tracheids of the latewood.

SIEVE PITTING OF PARENCHYMATOUS CELLS

The wood parenchyma cells of the redwood resemble the ray cells in having a primary wall of varying thickness but no true secondary wall. Thus, in the case of both wood parenchyma and rays, the primary walls of adjoining parenchymatous elements are provided with more or less numerous plasmodesmata which may be evenly and uniformly distributed or aggregated in primary pit-fields. Where the plasmodesmata are numerous and evenly distributed, *Fig. 48*, as in the end walls of many ray cells and wood parenchyma cells, the walls are relatively smooth in sectional view, *Fig. 49*. On the contrary, where the plasmodesmata are aggregated in primary pit-fields, *Figs. 50, 51, 53, 54, 56, 57,* and *58*, the walls appear to be beaded or unevenly thickened in sectional view, *Figs. 52, 55,* and *59*. It should be emphasized in this connection, however, that where the walls are as tenuous as they are in the primary pit-fields (white areas) of *Figs. 54, 56, 57,* and *58*, it is difficult to demonstrate the delicate sieve structure in photomicrographs.

The primary pit-fields vary in size, form, depth, number, and distribution in the various surfaces of the parenchymatous elements and in different parts of the tree. As previously stated, there may be a single large sieve field, *Fig. 48*, in the end walls of the parenchymatous elements or a varying number of more or less discrete sieve areas which are located in primary pit-fields, i.e., thinner areas of the primary walls. The former condition tends to be of more frequent occurrence in thin-walled than in thick-walled cells, in the narrow outer rings of old stems and roots than in the inner growth layers, and in ray parenchyma than in wood parenchyma. The primary pit-fields usually are more widely spaced in side walls, *Figs. 58* and *59*, than in end walls, *Figs. 54-56;* in the side walls of much elongated ray cells than of shorter ones; and of earlywood than of latewood. Furthermore, where the ray cells are very broad, fewer primary pit-fields are visible in a single focal plane of a radial section than where the ray cells are narrower. It should be emphasized, in this connection, that the smoother appearance of the upper and lower ray walls in radial sections of the redwood, as contrasted with similar sections of the Abietoideæ, is due, in large part, to the absence of pits to the intercellular spaces.

TRAUMATIC RESIN CANALS

The cambium of the redwood is extremely sensitive to traumatic stimuli and to abnormal environmental influence and tends to form arcs of resin canals, *Figs. 8, 12, 14-19*, which extend considerable dis-

tances beyond the principal focus of stimulation. In other words, an injury to the crown may induce the formation of resin canals not only in the injured branches, but in the stem as well. The cambium of *Sequoia sempervirens* differs, however, from that of *Sequoia gigantea*, and particularly from that of the various species of *Cedrus*, in not forming horizontal resin canals.

The resin-canals of the redwood vary greatly in size and shape, in the character and abundance of the specialized cells which jacket them, in the presence or absence of tylosoids, and in the position of the canals within the growth layers, *Figs. 14-19*. The schizogenous cavities may be minute, *Fig. 15*, or relatively large, *Fig. 14*. They may be angular, *Fig. 15*, oval, circular, *Fig. 16*, slit-like, *Fig. 17*, or irregular, *Fig. 14*. They may have a conspicuous and clearly differentiated epithelium, *Figs. 16* and *19*, or irregular jacketing mixtures of strand tracheids and parenchyma, *Figs. 14, 17*, and *18*. The location of the resin canals is determined by the season of the year at which the abnormal stimulus occurs. Thus, the canals may be located in the first-formed portion of the earlywood, *Fig. 18*, in the outer portion of the latewood, *Figs. 14, 15*, and *17*, or in various intermediate positions, *Figs. 16* and *19*. They tend, in general, to be of more frequent occurrence in the branches and roots of old trees than in the clear length of the stem. It is significant, however, that in certain parts of the range of the redwood, the crowns of trees growing in exposed situations are injured each year by severe storms which occur at specific periods during the growing season. The stems of such trees frequently form arcs or rings of resin canals in a large proportion of the successively formed growth layers, *Fig. 12*.

STRAND TRACHEIDS

The redwood exhibits a strong tendency to form numerous strand tracheids not only in close proximity to traumatic resin canals, but also upon the outer surface of the latewood of growth layers or parts of growth layers which are devoid of resin canals, *Fig. 31*. Not infrequently they are developed with such regularity in successively formed growth layers as to appear of normal occurrence, but are in all probability due to some periodically recurring environmental stimulus.

RAY TRACHEIDS

Ray tracheids are of extremely uncertain and sporadic distribution in the redwood (Gordon, 13; Holden, 17). They may be abundantly developed in stems which exhibit no evidences of wounding and may be entirely absent in severely injured specimens. They may be aggre-

gated in a single independent radial row or erratically distributed along the margin of the rays. Their size and shape are variable, and their walls may be smooth or provided with helical thickenings.

CONTENTS OF PARENCHYMA AND "RESINOUS" TRACHEIDS

The ray cells and wood parenchyma strands of the redwood commonly contain a varying amount of ergastic material which varies in color from light yellow or orange to reddish-brown, dark red, or nearly black. It may be distributed in irregular masses, in large globules, or in finely granular or alveolar forms. In the heartwood of old roots, and of many stems and branches, not only do the walls of the tracheids become saturated with more or less of this material, but it exudes into the lumina, where it frequently forms septa, or plugs, which appear spool-shaped in sectional view, *Fig. 60*. Tracheids which contain such biconcave septa are commonly referred to as resinous tracheids (Penhallow, 24; Record, 26).

DISCUSSION

As stated in our introduction, systems of classifying and identifying the woods of conifers and dicotyledons have developed largely through trial and error. In other words, each investigator assembles, or has access to, a collection of relatively small samples of the wood of various genera and species. These specimens are sectioned and are laboriously and minutely studied in a search for structural differences which may be utilized in the construction of keys. Each investigator finds that certain of the diagnostic criteria used by his predecessors are unreliable and replaces them by others of putatively greater conservatism.

The inherent difficulty in this method of approaching the problem is that available collections of woods are extremely heterogeneous assemblages of fragmentary specimens from different sources. Samples of the wood of one species or genus may be from old virgin forest trees, those of another species or genus from young second-growth forests, and those of a third from trees planted in botanic gardens or arboreta. Therefore, the prevailing conception of the structural characteristics of the xylem of any particular species or genus depends upon chance, i.e., upon the types of specimens which happen to be available in existing collections. Students of commercial timbers naturally confine their attention to the merchantable part of the tree; but the parts of the tree which eventually reach the market vary with the species, with the uses to which different woods are put, and with many other factors.

In the case of *Sequoia sempervirens*, the properties of the wood and the commercial requirements are such that the outer parts of the clear lengths of old slowly growing trees are prized for industrial utilization. Therefore, it is not surprising that in such manuals as those of Koehler (20) and Brown (5) wood of the general type shown in *Fig. 4* is selected for study and illustration. It is significant, however, that the detailed anatomical descriptions of Penhallow (24) and of other botanists and paleobotanists appear to be based largely upon the investigation of similar material. The prevailing conception of the anatomical characteristics of *Sequoia gigantea* likewise is based upon the study of material from the outer portions of huge old stems, whereas that of other species and genera frequently is derived from an examination of specimens from young or immature stems.

Our detailed study of the redwood, and our preliminary observations upon the range of structural variability in various representatives of the Pinaceæ, Araucariaceæ, Taxaceæ, Podocarpaceæ, Taxodiaceæ, and Cupressaceæ, indicate that most, if not all, of the anatomical characters which have been utilized for diagnostic purposes fluctuate more or less, not only in trees grown under markedly different environmental conditions, but also within different parts of a single individual. This is as true of such supposedly conservative qualitative characters as form and orientation of pits, or of pit apertures, as of such quantitative characters as width of annual rings, dimensions of cells, or number of rays per unit area. In general, the range of variability tends to be greater in different parts of a single large mature tree than in homologous parts of different trees of the same species. There are significant anatomical differences not only in comparable parts of stems, roots, and branches, but also in growth layers formed at successive intervals during the development of each of these organs. Thus, although wood from the outer parts of huge old stems may resemble that of the root, it usually differs considerably from the wood of younger stems, of branches, or of seriously suppressed or dwarfed stems.

It is evident, in view of such facts as these, that, if the problem of classifying and identifying the woods of gymnosperms and angiosperms is to be attacked from a thoroughly scientific point of view, collections of authentic specimens must be assembled, not only from different genera, species, and varieties, but also from different parts of mature trees and from trees growing under different environmental conditions. The available anatomical data—tabulated from miscellaneous collections and without due regard to significant developmental, physiological, and ecological factors—do not provide a reliable basis for dis-

tinguishing the woods of most closely related species or even of many remotely related ones. This is particularly true of fossilized specimens which may be derived from any part of the tree and where such macroscopic aids as color, odor, gloss, hardness, etc., are evanescent. Thus, although it is possible to differentiate the wood of *Sequoia* from that of the Taxaceæ, Araucariaceæ, Abietoideæ, and Pinoideæ, and to determine, for example, that *Sequoia Penhallowii* is, in reality, a representative of the Abietoideæ, it is difficult to distinguish the wood of *Sequoia*, in all cases, from that of the Podocarpaceæ, Cupressaceæ, and other genera of the Taxodiaceæ. As indicated on preceding pages, the pitting of rays and of wood parenchyma—upon which Penhallow (24), Gothan (14), Kräusel (21), Kanehira (19), Slyper (30), and others place so much reliance—may fluctuate markedly within a single tree or species. For example, the pits in the crossing fields of the rays (earlywood) of the redwood vary from "taxodioid" to "cupressoid," "podocarpoid," or "glyptostroboid," depending upon the source of the wood that is selected for investigation. Similarly, the structure of the end walls of the wood parenchyma, as seen in tangential longitudinal sections of the xylem, may be smooth or conspicuously beaded (Taxodium type), depending upon the part of the tree from which the wood is cut.

In the seventh paper of this series, it was shown that such putative transitional Mesozoic Coniferæ as *Protopiceoxylon, Planoxylon, Thylloxylon,* and *Protocedroxylon* fall within the range of structural variability of living representatives of the Abietoideæ. These genera are characterized, as are *Cedrus, Keteleeria, Abies, Tsuga, Pseudolarix, Larix, Pseudotsuga,* and *Picea,* by ray cells which form true secondary walls. The question arises, accordingly, whether other representatives of the hypothetical transitional Araucariaceæ, which do not exhibit this type of ray structure, fall within the range of anatomical variability of the Podocarpaceæ, Taxodiaceæ, or Cupressaceæ.

The salient arguments for regarding *Brachyoxylon, Paracedroxylon, Telephragmoxylon, Anomaloxylon, Paraphyllocladoxylon,* and *Paracupressinoxylon* as araucarians in disguise rather than as representatives of the Podocarpaceæ, Taxodiaceæ, or Cupressaceæ are the reputed absence of crassulæ and the occurrence, particularly towards the ends of the tracheids, of so-called araucarian pitting. Emphasis is frequently placed, in addition, upon the occurrence of "resinous" tracheids and of clusters of medullary stone cells, and upon the absence of wood parenchyma and of clearly defined growth layers.

Clusters of sclerides or stone cells, *Fig. 34,* are of not infrequent occurrence in the pith of the redwood and have been reported in

Torreya, *Podocarpus*, *Dacrydium*, and *Cryptomeria* (Seward, 28). Typical "resinous" tracheids, *Fig. 60*, are abundantly developed in many specimens of *Sequoia sempervirens* and are known to occur in *Pinus* and other conifers exclusive of the Araucariaceæ. Wood parenchyma may be entirely absent in specimens of the wood of various representatives of the Taxodiaceæ and Podocarpaceæ and may be present in the secondary xylem of living representatives of the Araucariaceæ. Similarly growth layers may be strikingly differentiated in the Araucariaceæ and feebly developed or absent in the Podocarpaceæ, Taxodiaceæ, and Cupressaceæ. Furthermore, contiguity and alternation of tracheary pitting is by no means an infallible criterion of araucarian affinity. We have shown that in the redwood, as in *Cedrus* and other representatives of the Abietoideæ, the tracheary pitting shifts at times from an opposite to an alternating orientation and from a widely spaced to a closely crowded arrangement. Such changes in the arrangement of the bordered pits tend to occur most readily at the ends of the tracheary cells. It should be emphasized, in addition, that where the pits shift to the so-called araucarian orientation, crassulæ and primary pit-fields are more or less completely eliminated. An investigation of a wide range of Podocarpaceæ, Taxodiaceæ, and Cupressaceæ reveals not only that contiguity and alternation of tracheary pitting are of more frequent occurrence than has been hypothesized, but also that where the pits are in opposite or widely spaced arrangement, the crassulæ may be so tenuous that they can be demonstrated only after delicately controlled differential staining. Primary pit-fields and crassulæ which are clearly visible in sapwood may be completely obscured during the transformation of sapwood into heartwood. To assume that these delicate structures of the primary walls are preserved in visible form in all material and under all conditions of fossilization is illogical.

It is evident, accordingly, not only that there are no convincing arguments for assuming that the various Paracupressinoxyla and Brachyphylleæ are transitional or ancestral types of Araucariaceæ, but also that most of them fall within the potential ranges of variability of the Podocarpaceæ, Taxodiaceæ, or Cupressaceæ. A number of them, obviously, exhibit combinations of anatomical characters which occur in living representatives of the genus *Sequoia*. For example, *Telephragmoxylon* was instituted for woods of putative araucarian affinities which are characterized by having strand tracheids upon the outer surface of the latewood. We have shown that the redwood has a pronounced tendency to form strand tracheids and that, in trees from

certain parts of the range of the species, these strand tracheids are present upon the outer surface of many successive growth layers and thus appear to be of normal occurrence. Not only are typical schizogenous resin canals, "resinous" tracheids, and clusters of medullary stone cells of frequent occurrence in the redwood, but wood parenchyma may be greatly reduced in amount and practically eliminated from certain specimens. Thus, in so far as one may judge from published descriptions and illustrations, both species of *Telephragmoxylon* fall within the range of structural variability of *Sequoia*, and may, in fact, be remains of this genus or of some closely related one.

It should be emphasized in conclusion that, in the present status of our knowledge concerning the variability of diagnostic criteria and in view of the difficulty of accurately determining the generic and even the sub-family affinities of many specimens, specific names as applied to fossil woods have no significance other than as aids in designating particular specimens. The word, "species," must be used for the present in an entirely different sense from that in which it is employed in systematic botany. Many of the supposedly distinct "species" of fossil woods may actually have been derived from the same species or even from different parts of a single tree. Conversely, specimens which are referred to a particular "species" may actually have been derived from different species or genera. It should not be inferred from this, however, that the problem of identifying plants by the structure of their secondary xylem is necessarily a hopelessly difficult one. Not only is there the possibility of ultimately finding structures or characters which are present in one genus or species and entirely absent in others, but the ranges of structural variability vary in different plants. Thus, the *combinations* of structural characters that occur in specific parts of the tree may fluctuate from species to species.

SUMMARY AND CONCLUSIONS

1. A detailed investigation of the secondary xylem of the redwood demonstrates that most anatomical characters fluctuate considerably not only in trees grown under markedly different environmental conditions but also within different parts of a single tree. This is as true of such supposedly conservative qualitative characters as form and orientation of pits, or of pit apertures, as of such quantitative characters as width of annual rings, dimensions of cells, or number of rays per unit area.

2. In general, the range of variability tends to be greater in different parts of a single, large mature tree than in homologous parts of

different trees. There are significant differences not only in comparable parts of stems, roots, and branches, but also in growth layers formed at successive intervals during the development of each of these organs.

3. In the redwood, as in other conifers, the cambial initials and their derivatives increase in size for a varying period of years, after which they tend to remain constant except where deviations are induced by various modifying factors. The cells of roots and of the outer parts of the clear lengths of huge old stems tend to be larger than those of young stems, of physiologically dwarfed stems, or of branches.

4. Many of the salient variations in the size, form, number, and orientation of pits and of primary pit-fields are correlated with such fluctuations in the size of cells and in the thickness and physical structure of their walls. Thus, different combinations of anatomical characters tend to prevail in different parts of a tree and in tissues formed under varying growth conditions.

5. A preliminary study of the ranges of structural variability in various representatives of the Coniferæ indicates that although it is possible to differentiate the wood of *Sequoia* from that of the Taxaceæ, Araucariaceæ, Abietoideæ, and Pinoideæ, it is difficult to distinguish it in all cases from that of the Podocarpaceæ, Cupressaceæ, and other genera of the Taxodiaceæ.

6. Characters which have been interpreted as indications of araucarian affinities—i.e., contiguity and alternation of tracheary pitting, absence of crassulæ and of wood parenchyma, occurrence of "resinous" tracheids and of clusters of medullary stone cells, etc., are of not uncommon occurrence in the redwood and other representatives of the Podocarpaceæ, Taxodiaceæ, and Cupressaceæ.

7. There are no convincing arguments for assuming that the various Paracupressinoxyla and Brachyphylleæ are transitional or ancestral types of Araucariaceæ, rather than forms related to the Podocarpaceæ, Taxodiaceæ, or Cupressaceæ. A number of them exhibit combinations of anatomical characters which fall within the potential range of structural variability of the genus *Sequoia*.

8. Systems of classifying and identifying the woods of gymnosperms and angiosperms have developed largely through trial and error. Available anatomical data—tabulated from miscellaneous collections of more or less fragmentary specimens and without due regard to significant developmental, physiological, and ecological factors—do not provide a reliable basis for distinguishing the woods of most closely related species and of many remotely related ones.

9. If the problem of classifying and identifying the woods of gymnosperms and angiosperms is to be attacked from a thoroughly scientific point of view, collections of authentic specimens must be assembled, not only from different genera, species, and varieties, but also from different parts of mature trees and from trees growing under different environmental conditions.

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DESCRIPTION OF PLATES

PLATE 99

Sequoia sempervirens

Figs. 1-5. *Stem.* Transverse sections of the xylem, showing structural details of growth layers at successive intervals between the pith and bark of a large stem. × 32.

PLATE 100

Sequoia sempervirens

Fig. 6. *Stem.* Transverse section of the xylem from the outermost portion of an old tree, showing wide layer of "compression wood." × 32.

Figs. 7 & 8. *Branch.* Transverse sections of the xylem, showing growth layers from the inner and outer parts of an old branch. × 32.

Fig. 9. *Branch.* Transverse section of the xylem from the under side of an old branch, showing "compression wood." × 32.

Fig. 10. *Root.* Transverse section of the xylem of an old root. × 32.

PLATE 101

Sequoia sempervirens

Fig. 11. *Stem.* Transverse section of the xylem of a young vigorous tree, showing wide growth layer and gradual transition between earlywood and latewood. × 17.

Fig. 12. *Stem.* Transverse section of the xylem, showing traumatic resin canals in the latewood of three successive growth layers. × 17.

Fig. 13. *Stem.* Transverse section of the xylem, showing wide growth layer formed after a prolonged period of suppression. × 17.

PLATE 102

Sequoia sempervirens

Figs. 14, 17-19. *Stem.* Transverse sections of the xylem, showing various types of traumatic resin canals. × 54.

Fig. 15. *Root.* Transverse section of the xylem of a young root, showing traumatic resin canals. × 54.

Fig. 16. *Root.* Transverse section of the xylem of an old root, showing traumatic resin canals. × 54.

PLATE 103

Sequoia sempervirens

Figs. 20-25. *Stem.* Radial longitudinal sections of the xylem, showing variations in the form and in the distribution of primary pit-fields, crassulæ, and bordered pits in thin-walled tracheids of varying diameters. × 255.

Figs. 27-29. *Root.* Radial longitudinal sections of the xylem, showing compressed and alternating arrangements of bordered pits. × 255.

Figs. 26 & 30. *Stem.* Radial longitudinal sections of the xylem, showing variations in the size and form of the torus. × 1680.

PLATE 104

Sequoia sempervirens

Fig. 31. *Stem.* Tangential longitudinal section of the xylem, showing strand tracheids, rays, and bordered pits. × 54.

Fig. 34. *Stem.* Transverse section of the pith, showing cluster of stone cells. × 73.

Figs. 32, 33, 35-37. *Stem.* Tangential longitudinal sections of the xylem, showing common variations in the size and form of rays and of their constituent cells. × 54.

PLATE 105

Sequoia sempervirens

Figs. 38-43, & 45. *Stem.* Radial longitudinal sections of the *first formed part* of the earlywood of various growth layers, showing variations in the size, form, number, and orientation of bordered pits in the "crossing fields" of the rays. × 1210.

Fig. 44. *Root.* Radial longitudinal section of the xylem of a young root, showing orientation of bordered pits in the crossing field of a ray. × 1210.

Fig. 46. *Stem.* Transverse section of the xylem, photographed with polarized light. × 965.

Fig. 47. *Stem.* Transverse section of "compression wood," photographed with polarized light. × 965.

PLATE 106

Sequoia sempervirens

Figs. 48 & 51. Tangential longitudinal sections of the xylem, showing surface views of the sieve pitting in the end walls of ray cells. × 500.

Figs. 50, 53, 54, 56, & 57. Transverse sections of the xylem, showing primary pit-fields and sieve pitting in the end walls of wood parenchyma. × 500.

Figs. 49, 52, 55. Tangential longitudinal sections of the xylem, showing sectional views of the end walls of wood parenchyma. × 500.

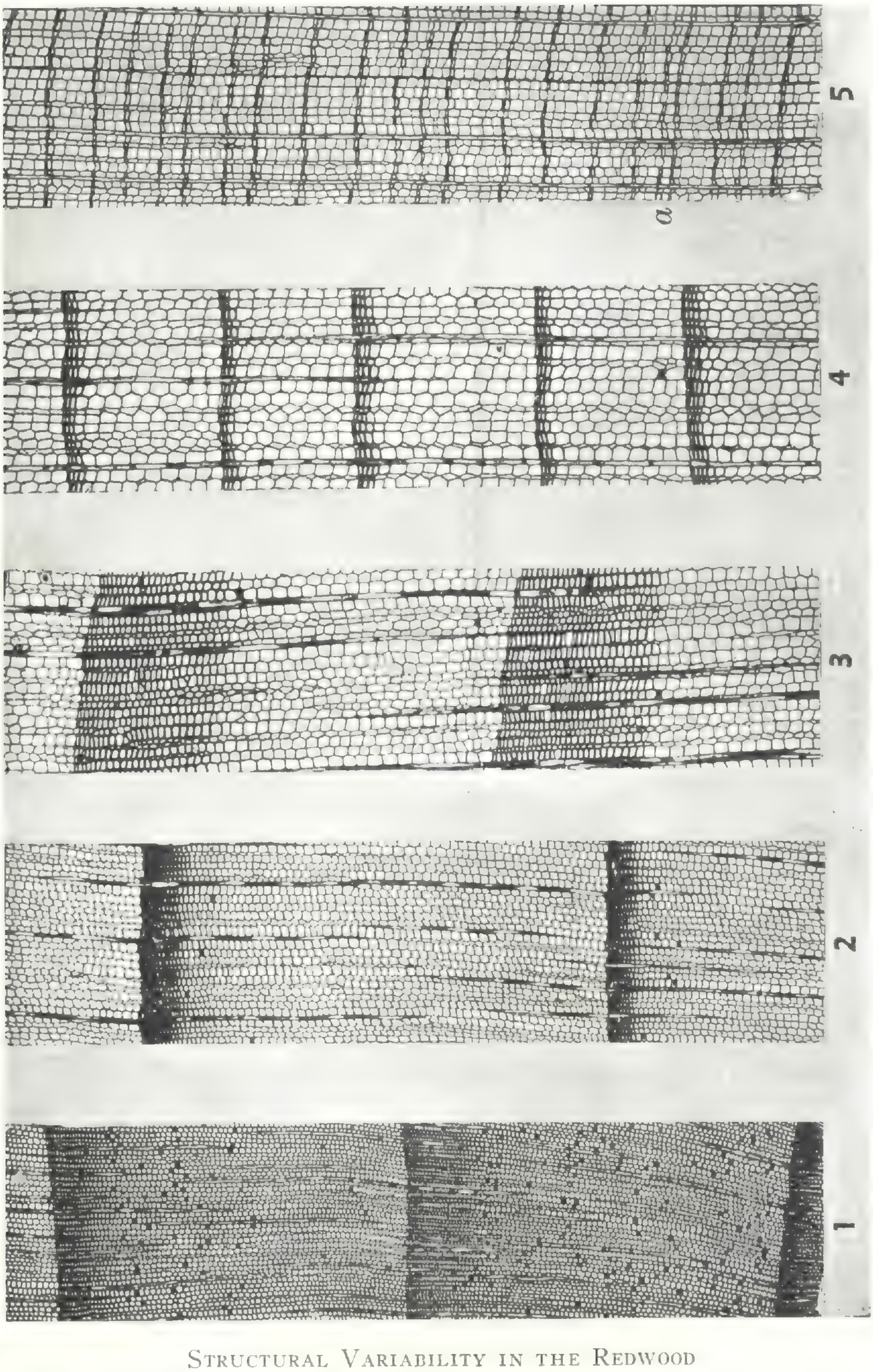
Fig. 58. Transverse section of the xylem, showing surface view of the wall of a ray cell. × 500.

Fig. 59. Tangential longitudinal section of the xylem, showing sectional view of the lateral walls of wood parenchyma. × 500.

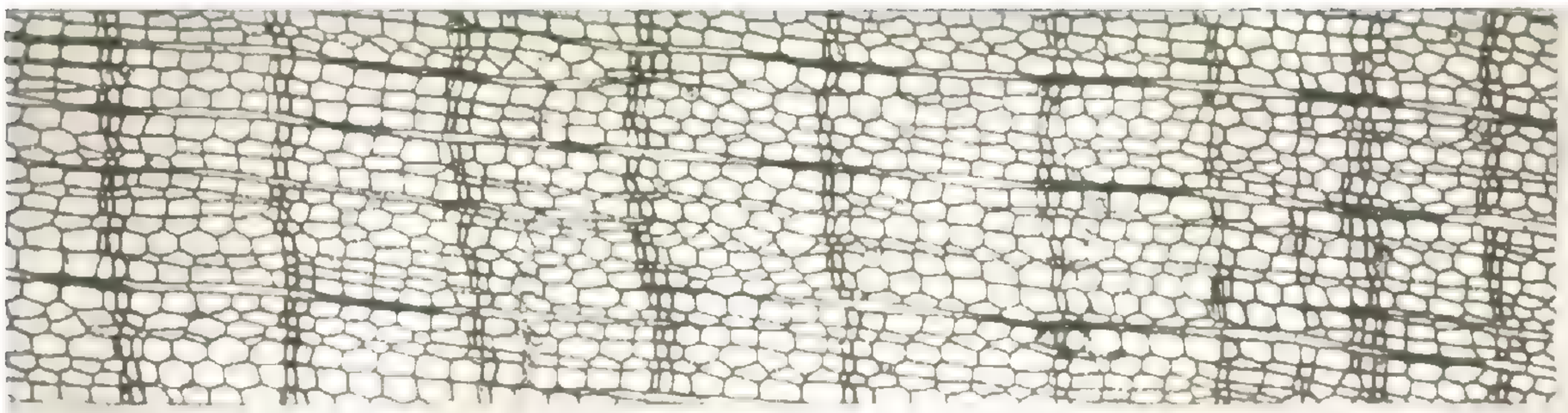
Fig. 60. Radial longitudinal section of the xylem, showing "resinous tracheids." × 170.

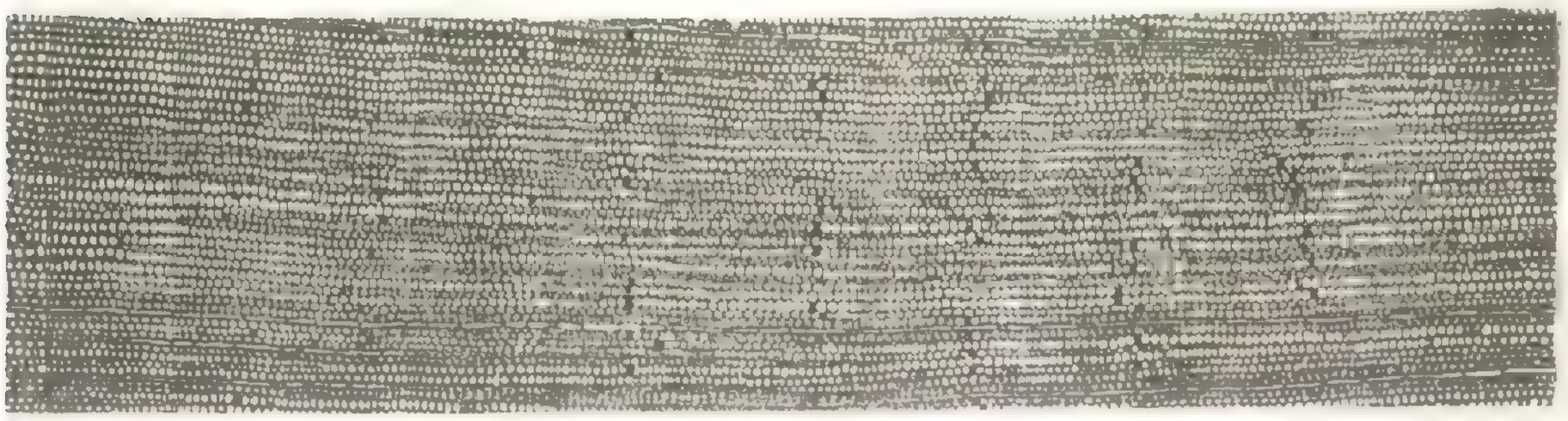
Figs. 61-62. Tangential longitudinal sections of the xylem, showing details of ray structure. × 500.

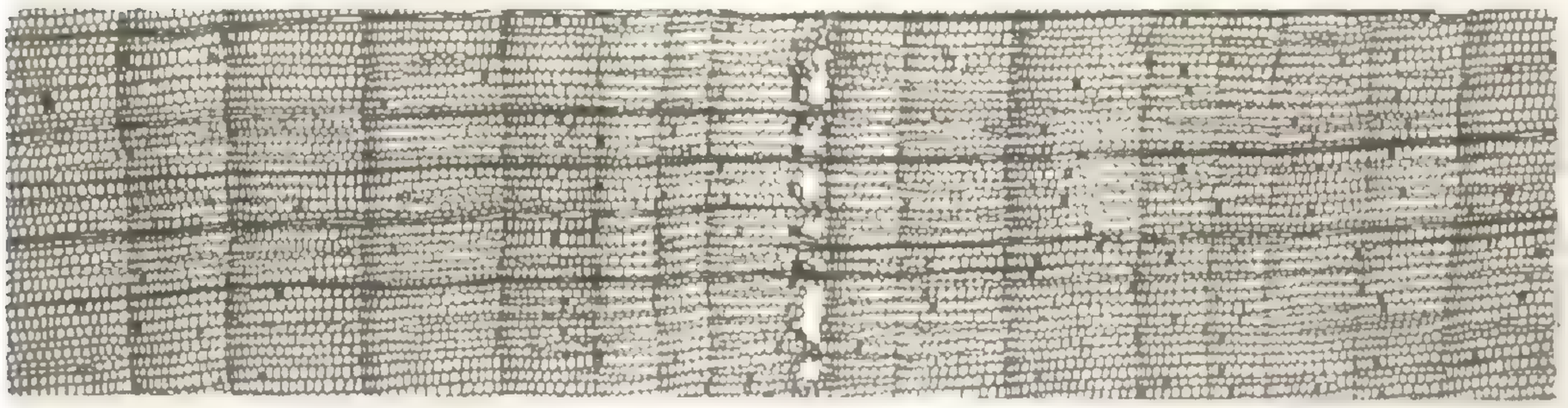
ARNOLD ARBORETUM, HARVARD UNIVERSITY, AND
CARNEGIE INSTITUTION OF WASHINGTON.

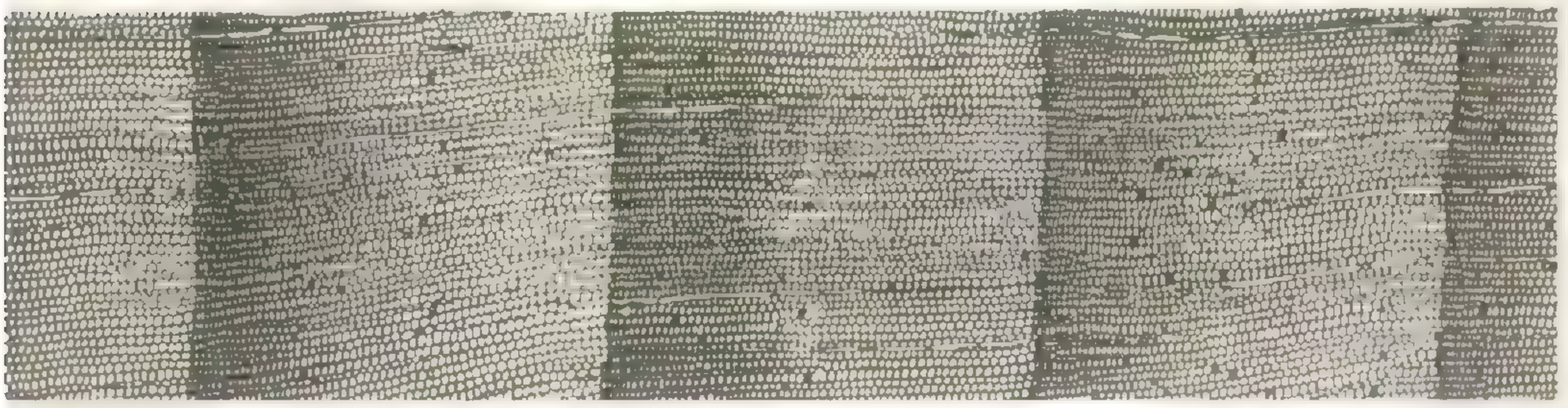


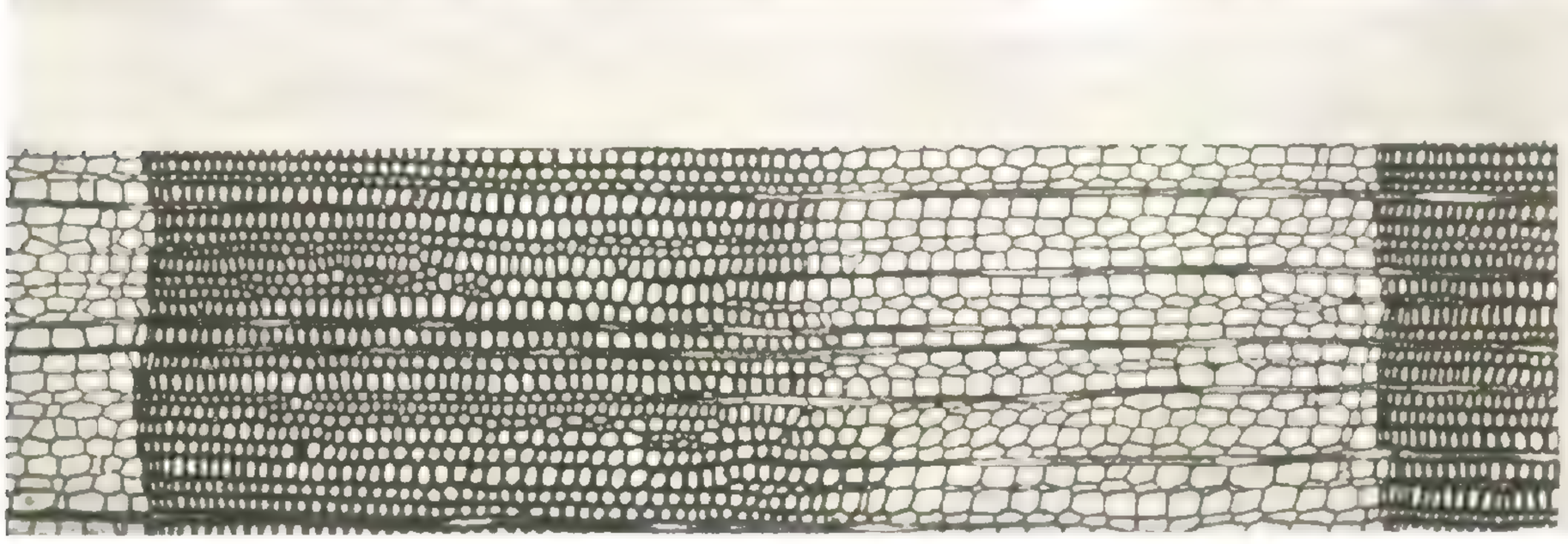
STRUCTURAL VARIABILITY IN THE REDWOOD











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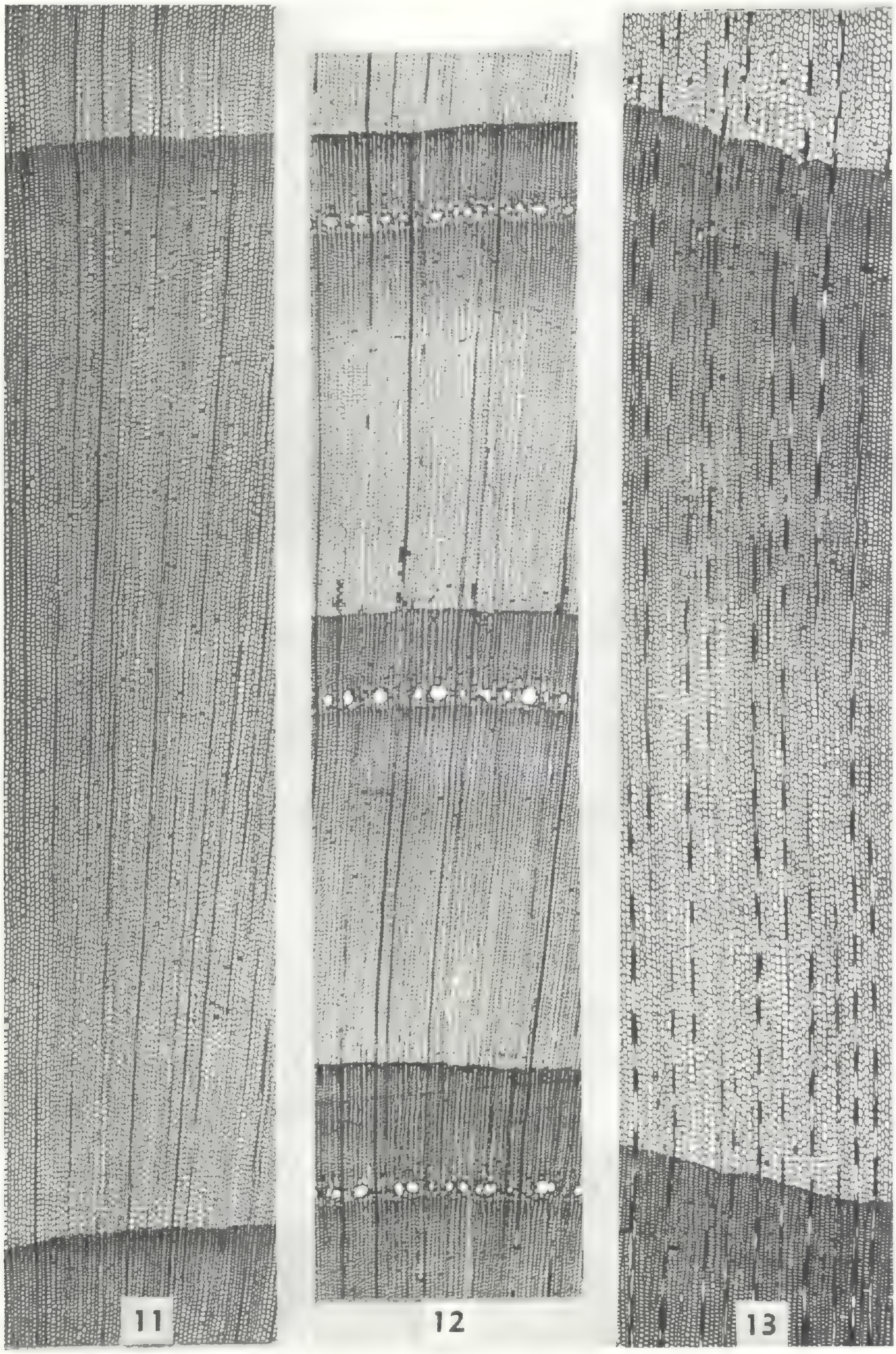

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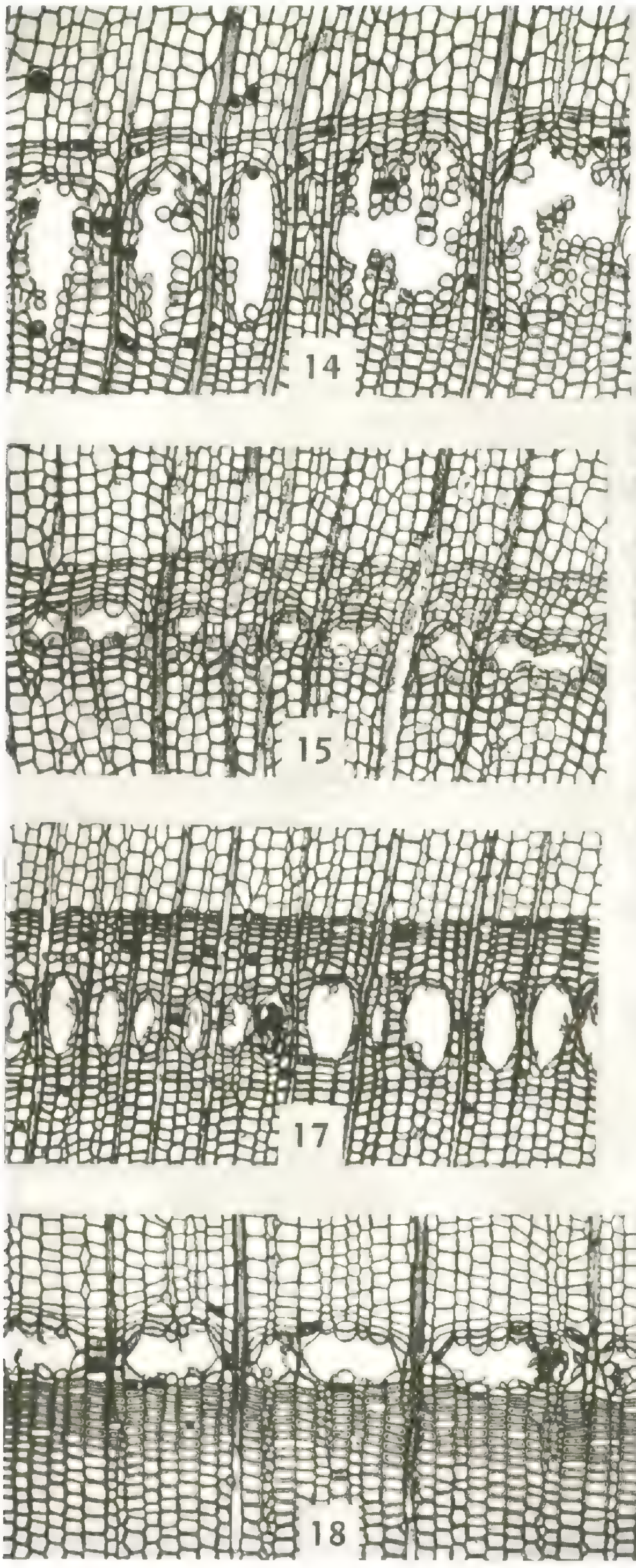

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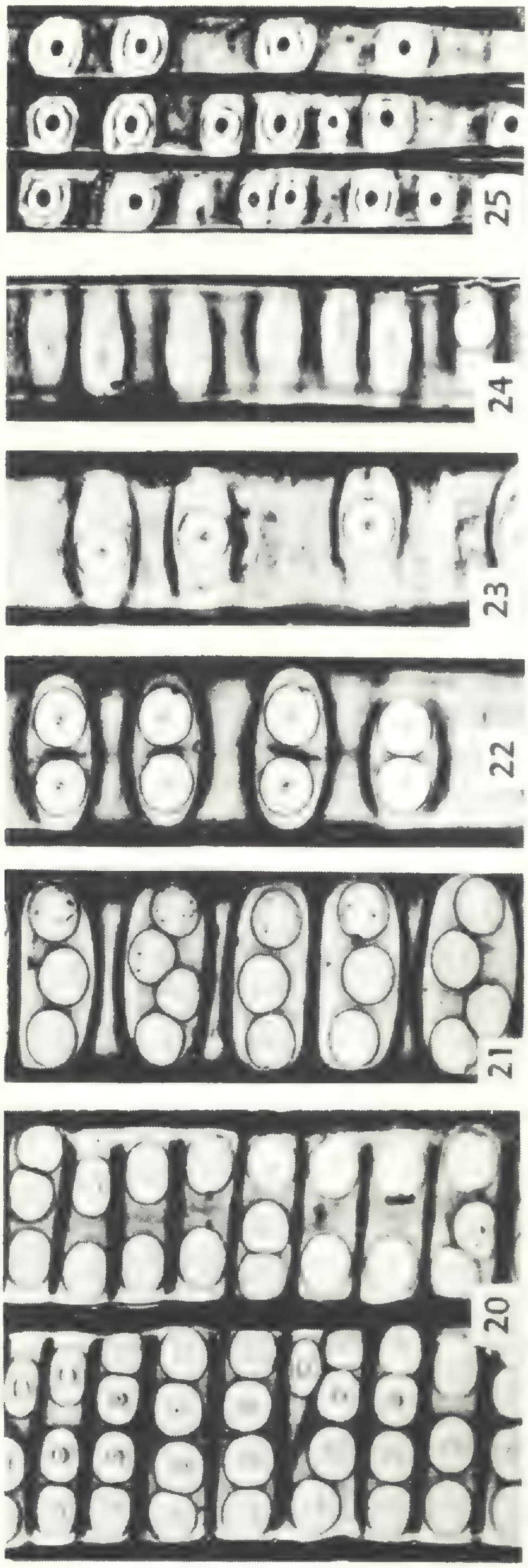
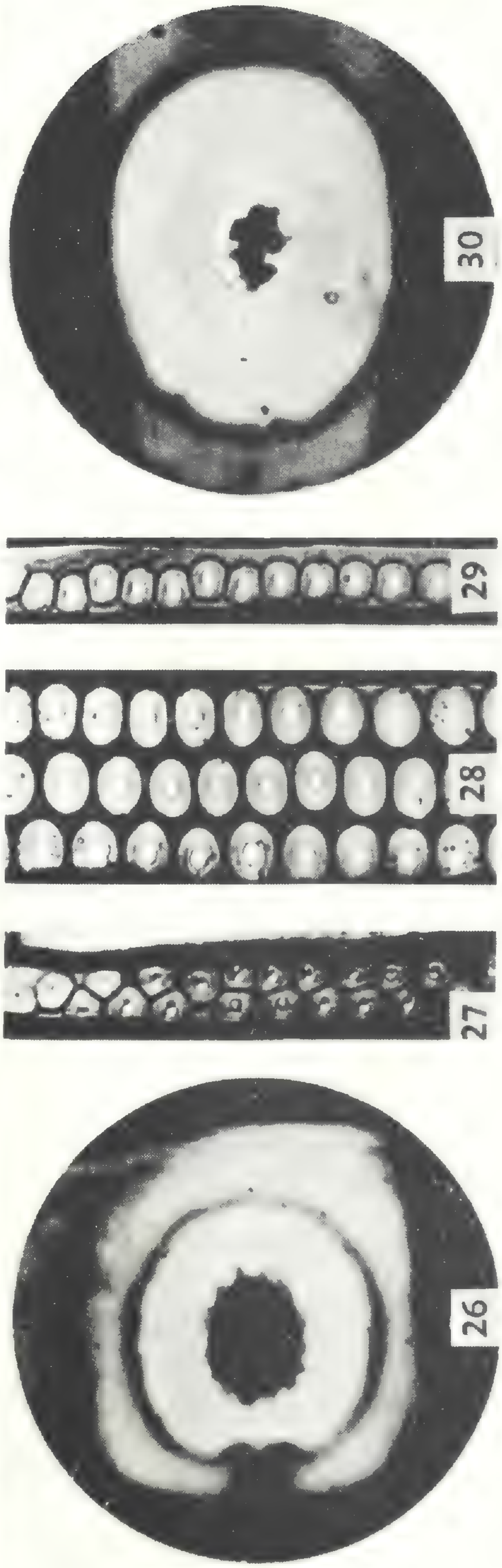
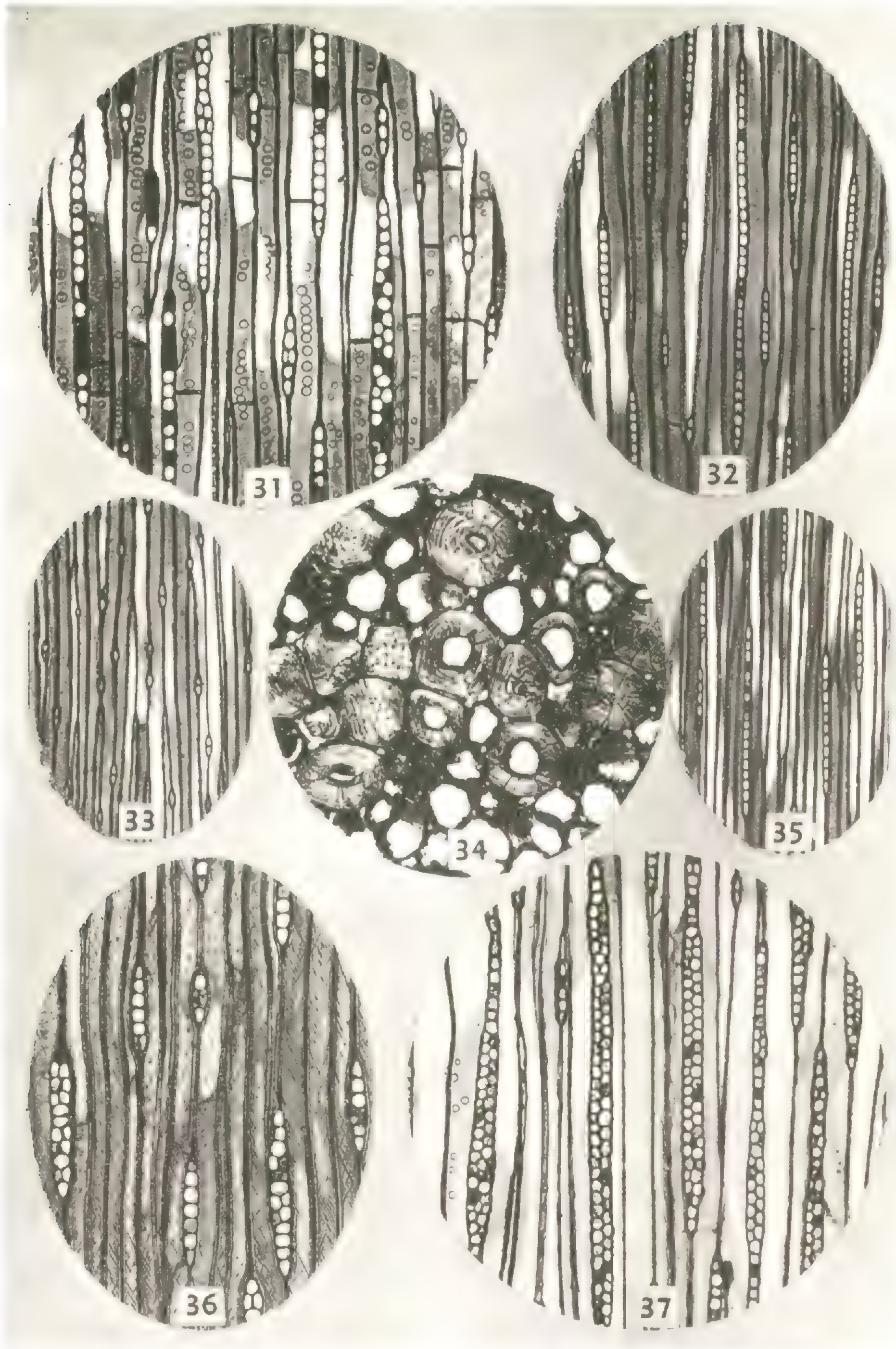




STRUCTURAL VARIABILITY IN THE REDWOOD

THE HELIOTYPE CORP. BOSTON



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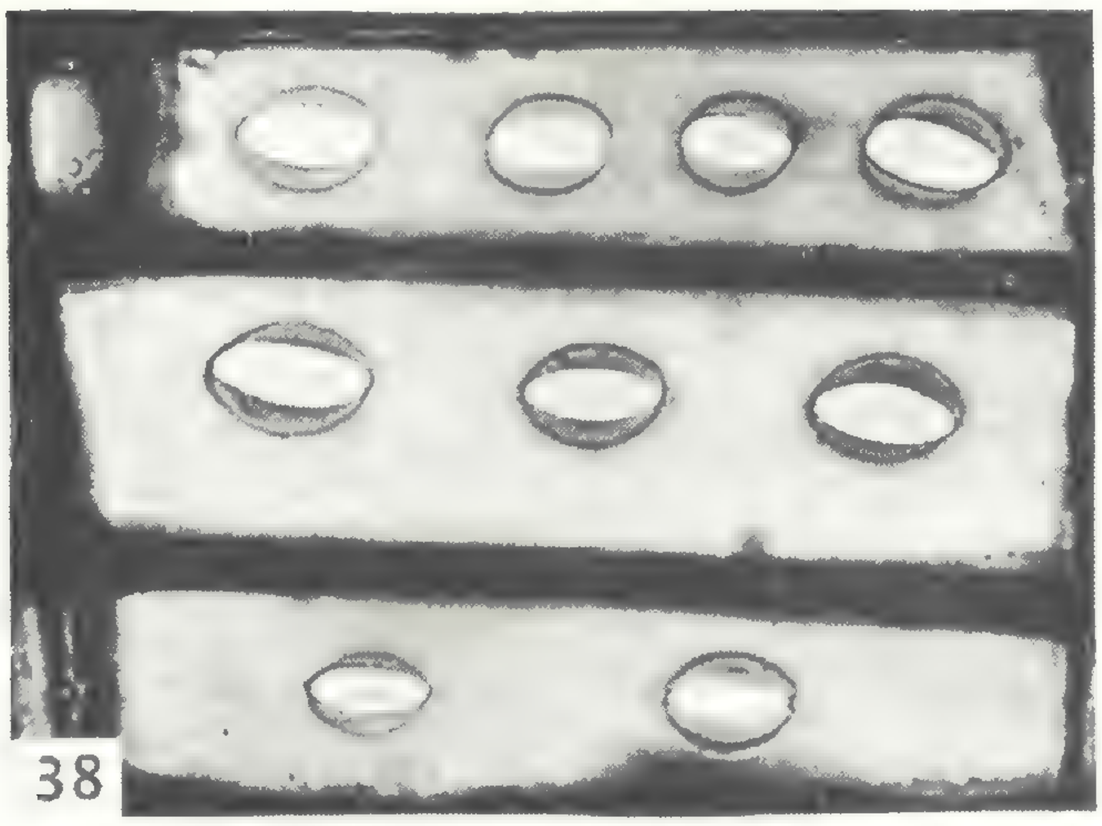
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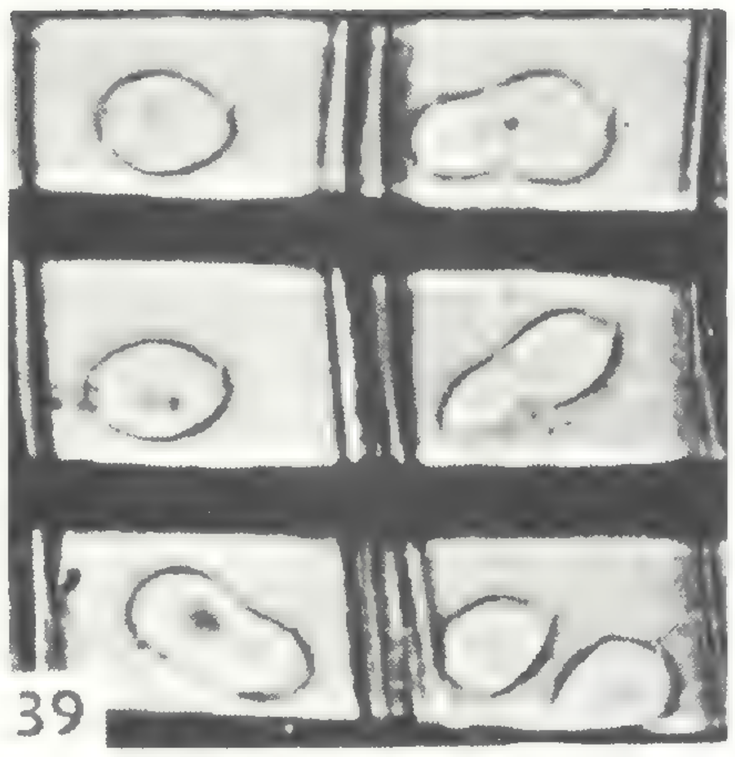
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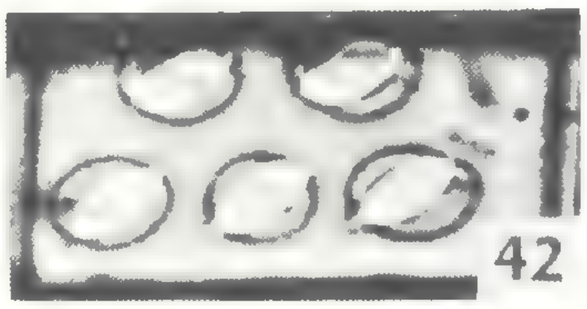
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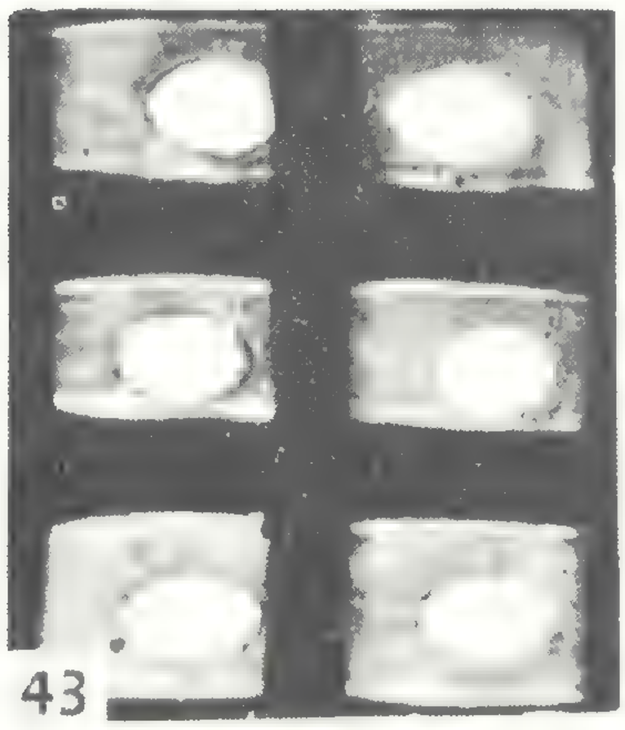
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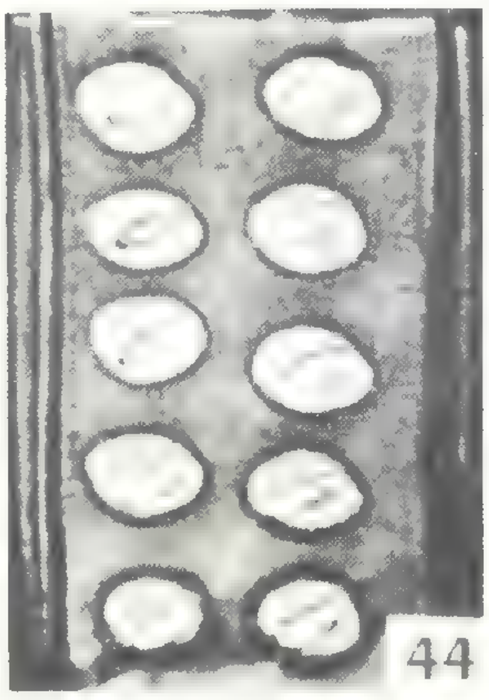
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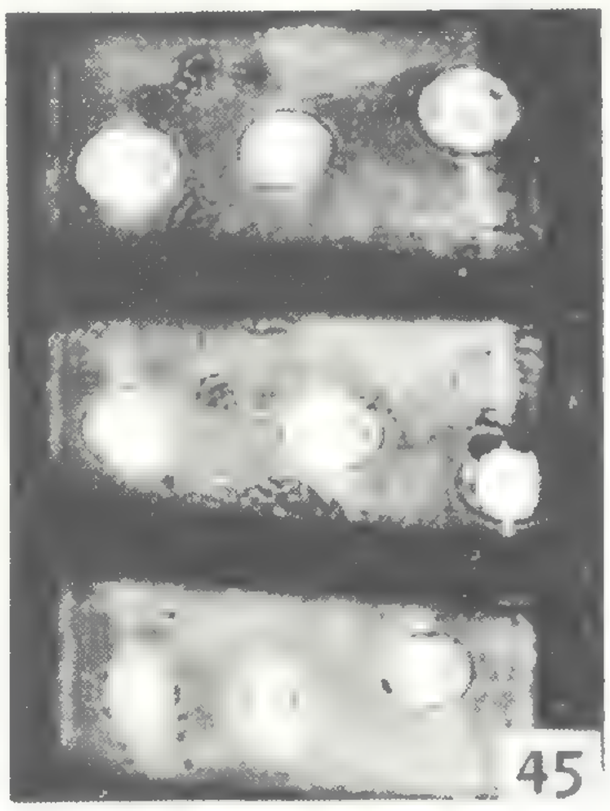
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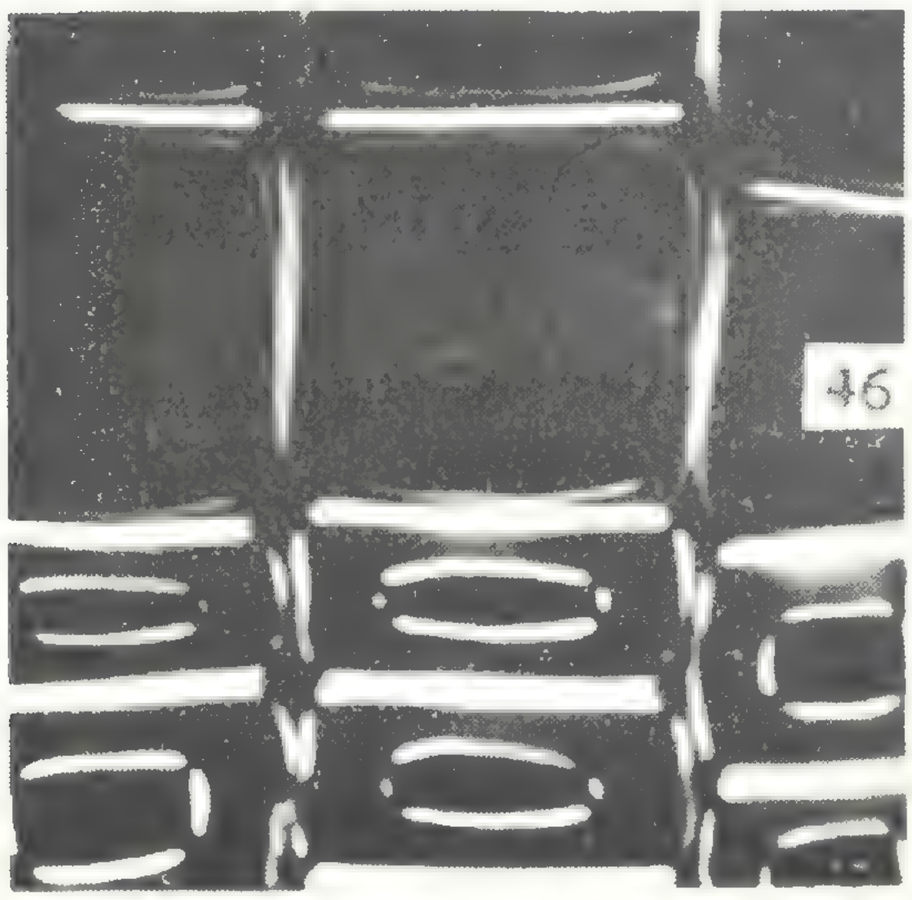
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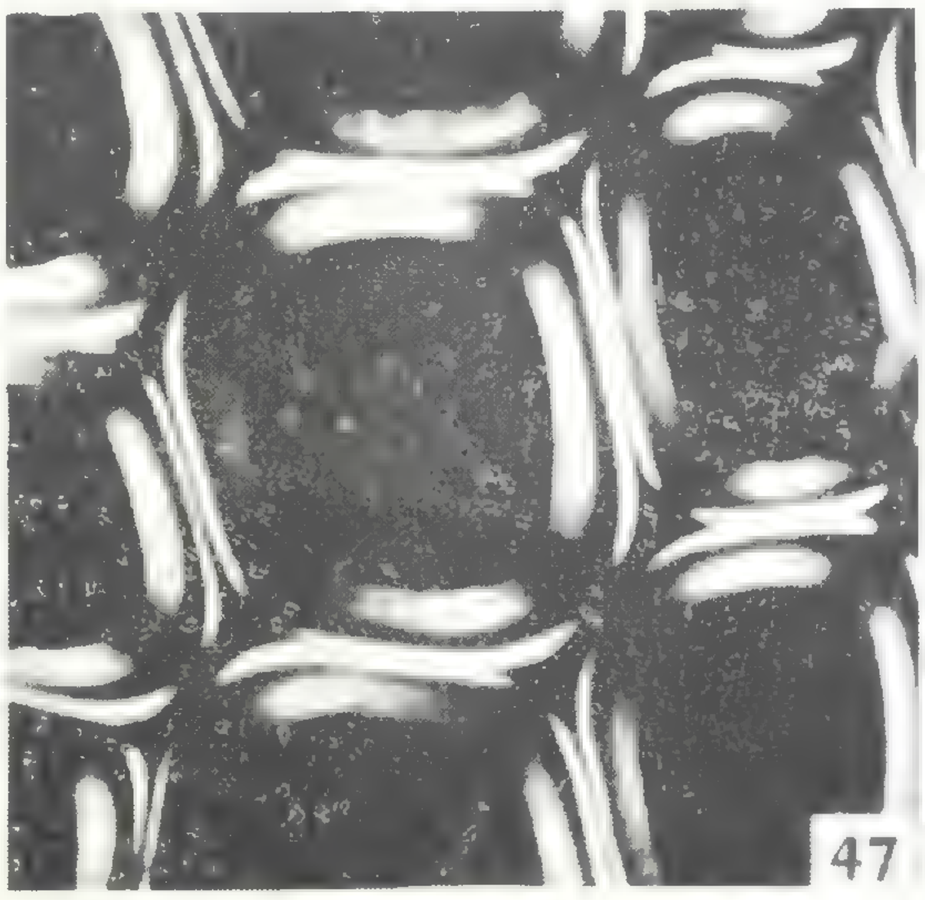
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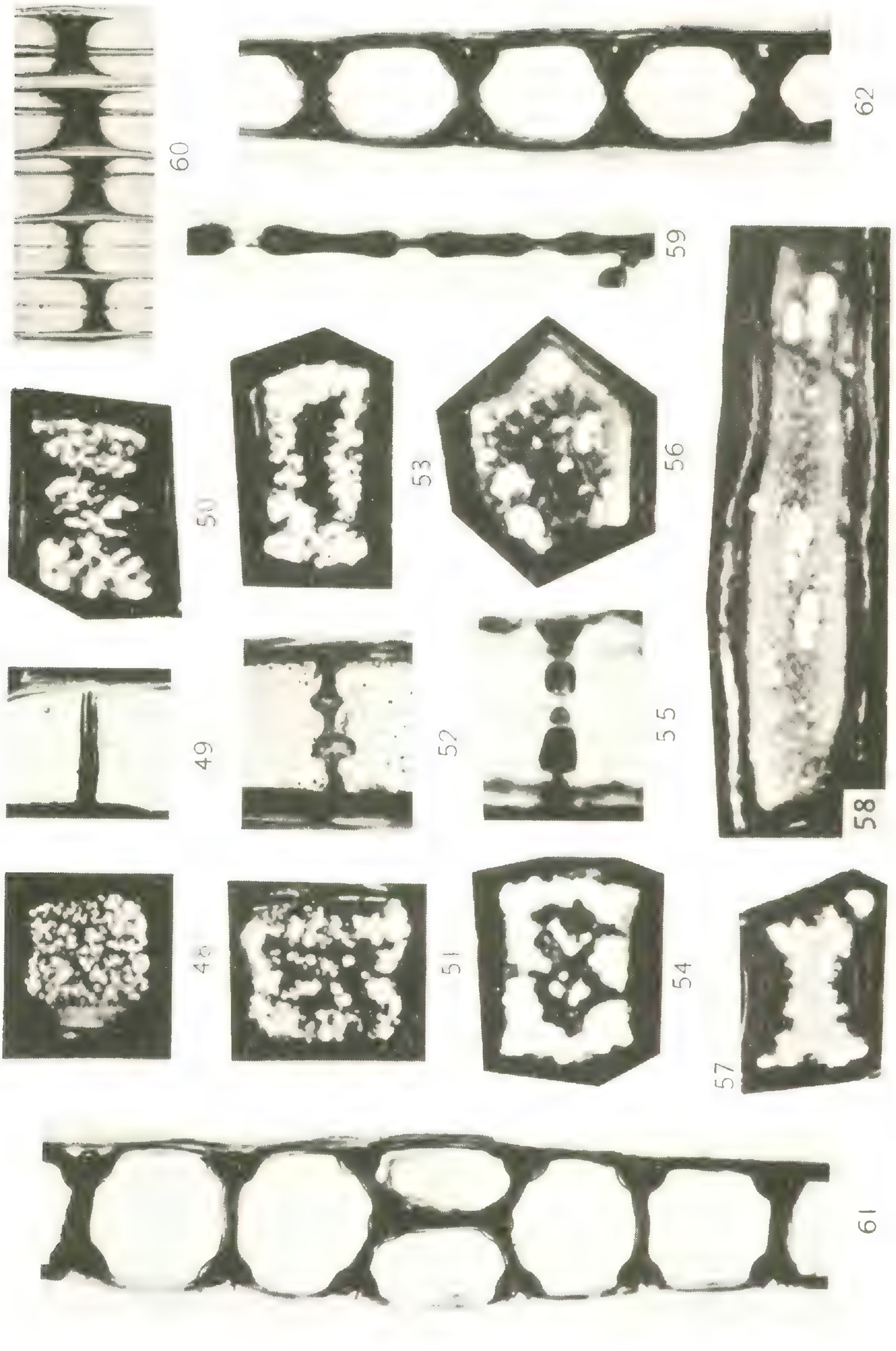
Structural Variability in the Redwood

THE HELIOTYPE CORP. BOSTON



STRUCTURAL VARIABILITY IN THE REDWOOD

THE HELIOTYPE CORP. BOSTON

CHROMOSOMES OF THE CYCADALES

KARL SAX AND J. M. BEAL

With plates 107 and 108

THE CYCADS are the most primitive of the living gymnosperms and represent the surviving remnants of a line reaching back through the Mesozoic into the Paleozoic era. Nine genera, containing less than one hundred species, are recognized. Four of the genera occur exclusively in the western hemisphere and the other five in the eastern.

Of the western genera, *Zamia*, with twenty-six species, ranges from southern Florida to Chile. *Microcycas* is a monotypic genus and is found only in western Cuba. *Dioon*, with three species is found only in southern Mexico, and *Ceratozamia* with two species has about the same range as *Dioon*.

Of the eastern genera, *Cycas*, with eight species, ranges from Japan to Australia. *Macrozamia*, with nine species and the monotypic *Bowenia* occur in Australia. *Encephalartos*, with fourteen species and *Stangeria*, a monotypic genus, are found in southeastern Africa.

The basic chromosome number has been reported as 12 in most gymnosperms including the cycads, but recent work has shown that many of the earlier counts were incorrect (Sax and Sax 1933). The chromosome number and morphology in the gymnosperms is best obtained from the haploid endosperm cells, but it was so difficult to obtain female cones from most cycads that root tip preparations have been used almost exclusively. The root tips were fixed in acetic acid alcohol, and aceto-carmine smears were made from this material.

Material for the cytological investigation has been obtained from a number of sources. Female cones of *Zamia* were obtained from Mr. Robert Gray, superintendent of the Atkins Institution of the Arnold Arboretum at Soledad, Cuba. Dr. Edgar Anderson obtained root tips from several genera at the New York Botanical Garden, and some material was sent from the University of Pennsylvania by Dr. Conway Zirkle. Most of the material was obtained from Dr. Chamberlain's collection of cycads at the University of Chicago by the junior author.

So far as possible, we have followed Schuster's classification of the Cycadaceae (Engler, 1932). The following genera and species have been studied:—*Cycas revoluta* Thunb., *C. circinalis* L., *C. Rumphii* Miq., *Bowenia serrulata* André, *Macrozamia tridentata* (Willd.) Regel, *M. Miquelii* (F. Muell.) Schuster, *M. Moorei* F. Muell., *Stangeria paradoxa* Th. Moore, *Encephalartos Altensteinii* Lehmann, *Dioon spinulosum* Dyer, *Microcycas calocoma* (Miq.) A. DC., *Ceratozamia*

mexicana Brongn., *C. mexicana* var. *longifolia* (Miq.) Schuster, *Zamia floridana* A. DC. and two varieties of *Z. media* Jacq., var. *Gutierrezii* (Sauvalle) Schuster and var. *portoricensis* (Urban) Schuster. Two species collected as *Cycas* "Wadel" and as *Zamia pumila* L., could not be placed definitely according to Schuster's classification.

The chromosomes can be studied most readily in the "endosperm" cells. A few such preparations were obtained from female cones of *Zamia*. The chromosomes of most species examined were studied in aceto-carmine smears of root tips. In most cases it was possible to determine the chromosome number and morphology quite accurately. The chromosomes are large and in the smear preparations they are spread out in nearly the same focal plane. Photographs of the somatic chromosomes of several genera are shown in plate 107. The chromosomes of other genera and species are pictured in plate 108. Only two good division figures were obtained from *Bowenia* and in these the chromosomes were so widely scattered in smearing that it was impracticable to represent them in the photographs or drawings. *Dioon* also proved to be difficult, and in *D. edule* there appeared to be only 16 chromosomes in some figures, but these were not clear enough to establish a definite count. The chromosome numbers of *Zamia* species were obtained from both endosperm and root tips. A summary of the chromosome number and morphology of the different genera is shown in table I.

TABLE I.

CHROMOSOMES OF CYCADS

Species	Terminal fiber	sub-term. fiber	median fiber	Total 2 n.
Cycas revoluta	10	8	4	22
Cycas circinalis	10	8	4	22
Cycas Rumphii	10	8	4	22
Bowenia serrulata		6	12	18
Macrozamia tridentata	2	6	10	18
Macrozamia Miquelii	2	6	10	18
Macrozamia Moorei	2	6	10	18
Stangeria paradoxa	2	2	12	16
Encephalartos Altensteinii		4	12	16
Dioon spinulosum		10	8	18
Microcycas calocoma	22	2	2	26
Ceratozamia mexicana		4	12	16
C. mexicana var. longifolia		4	12	16
Zamia media				
var. Gutierrezii		4	12	16
var. Commeliniana		4	12	16
var. portoricensis		4	12	16
Zamia floridana		4	12	16

In several genera, chromosomes are found with apparently terminal spindle fiber attachment points. These are especially clear as the chromosomes begin to separate at late metaphase. There is so much variation in chromosome size in different cells of a single individual that it was seldom possible to establish any consistent difference in chromosome size in different genera. The chromosomes of *Cycas* seem to be relatively shorter than those of other genera. The relative lengths of the chromosomes and the positions of the spindle fiber attachment points are consistent within each genus.

The chromosome number and morphology may differ considerably in different genera but the genoms of the species within each genus seem to be very similar, a condition also found in the Coniferales (Sax and Sax 1933). *Zamia* and *Ceratozamia* are similar in chromosome number and morphology. According to Chamberlain (1926) these genera have been crossed and the *Zamia* (male) parent was found to be dominant in F_1. Both the cytological and genetic data would indicate that these two genera are closely related.

The chromosome numbers in the cycads differ from those in the typical conifers. The basic haploid numbers are 8, 9, 11, and 13 for the cycads and the lower numbers 8 and 9, are most characteristic. In the conifers the basic number is 12 for the Taxaceae, although recent studies indicate that *Podocarpus* has 20 pairs of chromosomes. The basic number is 12 for most *Abieteae* and 11 for the *Cupresseae* and *Taxodieae*, with the exception of *Sciadopitys* which has 10 pairs of chromosomes. The basic chromosome numbers are 12 for the Ginkgoales and 7 for the Gnetales. The chromosomes are large in most gymnosperms, but *Gnetum* has a large number of relatively small chromosomes.

In general the chromosome numbers show some correlation with the taxonomic grouping of the gymnosperms. There is, however, little cytological evidence for any relation between existing gymnosperms and the angiosperms. If the angiosperms have been derived from the gymnosperms we must go back to extinct forms for the ancestral types.

SUMMARY

The haploid chromosome numbers in the Cycadaceae are as follows: *Cycas* 11, *Bowenia* 9, *Macrozamia* 9, *Stangeria* 8, *Encephalartos* 8, *Dioon* 9, *Microcycas* 13, *Ceratozamia* 8, and *Zamia* 8. Different genera may vary considerably in chromosome morphology, but species within each genus have similar chromosomes.

LITERATURE CITED

CHAMBERLAIN, C. J. (1926). Hybrids in Cycads. (Bot. Gaz. **81**:401–418.)

SAX, KARL & HALLY J. SAX (1933). Chromosome number and morphology in the conifers. (Jour. Arnold Arb. **14**:356–375.)

SCHUSTER, J. (1932). In Engler, Pflanzenreich, IV-1 (Cycadaceae), pp. 168. W. Engelmann, Leipzig.

EXPLANATION OF PLATES

PLATE 107

Photographs of cycad chromosomes. Aceto-carmine smears of root tips.
Photo. 1. Cycas revoluta.
Photo. 2. Microcycas calocoma.
Photo. 3. Zamia media var. portoricensis.
Photo. 4. Zamia pumila.

PLATE 108

Chromosomes of cycads.
Aceto-carmine smears. × 1000.
Figs. 1-7 from root tip cells. Fig. 8 from endosperms.

Fig. 1. Cycas revoluta.
Fig. 2. Cycas "Wadel."
Fig. 3. Macrozamia tridentata.
Fig. 4. Stangeria paradoxa.
Fig. 5. Encephalartos Altensteinii.
Fig. 6. Dioon spinulosum.
Fig. 7. Ceratozamia mexicana.
Fig. 8. Zamia media var. Gutierrezii.

ARNOLD ARBORETUM, HARVARD UNIVERSITY AND
DEPARTMENT OF BOTANY, UNIVERSITY OF CHICAGO.

CHROMOSOMES OF THE CYCADALES

THE HELIOTYPE CORP. BOSTON

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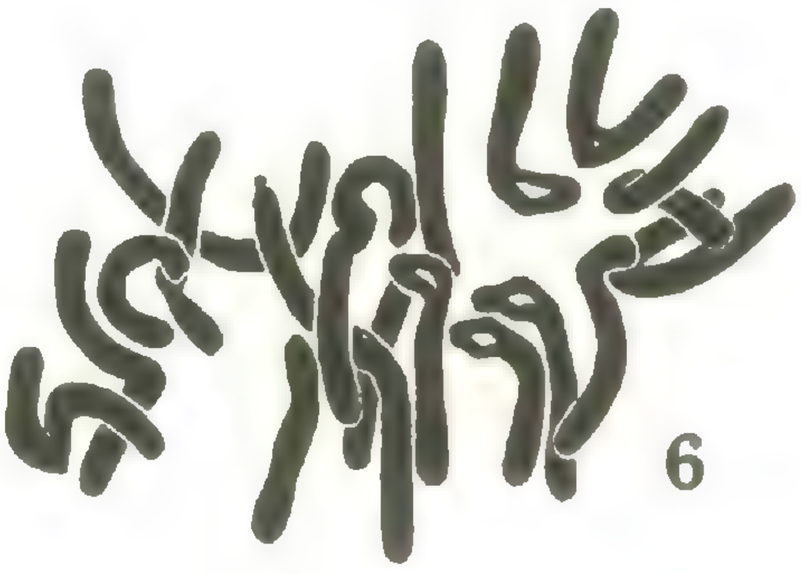
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Chromosomes of the Cycadales

THE SEVENTH CENTURY OF THE RELIQUIAE FARLOWIANAE

DISTRIBUTED BY THE FARLOW HERBARIUM OF HARVARD UNIVERSITY

DAVID H. LINDER

With plate 109

THE SEVENTH CENTURY of the Reliquiae Farlowianae is being issued as a memorial to the late Professor Roland Thaxter and as a token of appreciation for the many valuable services that he rendered the Farlow Herbarium during his career as a mycologist. Since, during the latter days of his life, Professor Thaxter explicitly stated that it was his wish that the specimens be utilized for the continuation of the Reliquiae Farlowianae, and also that he did not wish another set to be issued under his name, the seventh century becomes a memorial not only to Professor Thaxter but also a tribute to his devotion and loyalty to his former teacher, Professor W. G. Farlow.

Because of the nature of the seventh century, it is composed almost exclusively of specimens collected by Professor Thaxter himself, and therefore it includes types of many of the species which he found opportunity to publish in the earlier days of his career. Since such is the case, many mycologists who have been under the impression that Professor Thaxter's interests were solely confined to the Laboulbeniales, may be surprised to learn how broad his interests really were. To those who were more intimately acquainted with him, and who must often have been impressed by his accurate and detailed knowledge of widely separated groups of fungi, it is hoped that this century of the Reliquiae Farlowianae may recall pleasant associations.

Many of the specimens of this set have been determined by specialists but a large number were named by Professor Thaxter himself, and since the names assigned by him represented his ideas, they have been retained. Undoubtedly, had time permitted, he would have changed many of the names to conform with the nomenclature of more recent monographic treatments. Accordingly, in a few instances the preferable name, as accepted in the Bibliographic Index of the Farlow Herbarium, has been added below that assigned by Professor Thaxter. The same remarks also apply to a few of the Uredinales which were determined by Professor J. C. Arthur. The lichens have been treated in a similar manner and the names accepted by Zahlbruckner have

been added in order that the nomenclature conform to that in the Catalogus Lichenum Universalis.[1]

As was true of the previous six centuries, this one will shortly be sent out to various botanical institutions in this country and abroad. Because of the fact that only thirty-six sets are available for distribution, preference will be given to those institutions which already possess the first six centuries, and especially to those which have sent specimens in exchange for the sets already issued. Should any institution that has already received the earlier centuries of the Reliquiae Farlowianae not receive this continuation within a reasonable length of time, the writer, upon notification, will be only too glad to rectify any oversight.

In connection with the issuing of this century, it is necessary to describe one new species, as represented by no. 629, namely *Phyllachora Buddleiae* Arnaud and an associated conidial phase. This specimen was sent to Professor Arnaud for determination and he returned it with the above name and a description, but stated that he did not intend to follow the matter further. Accordingly the description follows:

Phyllachora Buddleiae Arnaud, sp. nov. Plate 109

Fructificationes numerosae, minutae, atrae, orbiculatae et leniter rotundato-elevatae, 200-350 μ diam., maculis orbicularibus, discoloribus, 0.3-2 cm. diam. superne insidentes; clypeo atro amphigeno vel raro tantummodo epigeno, 72-285 μ diam., 10-72 μ crassitudine, clypeo supero ostiolato; loculis solitariis subglobosis vel applanatis, 243-360 × 126-255 μ, parietibus tenuibus, hyalinis vel subhyalinis; ascis late clavatis, 72-100 × 19.5-31 μ, octosporis; sporidiis irregulariter distichis, oblongis, utrinque obtusis, continuis levibus hyalinisque, 19.5-25.5 × (12.5)-14.5-16.5 μ; paraphysibus hyalinis, filiformibus, tenuibus, flexuosisque, simplicibus vel interdum parce ramosis, 72-90 × 2.5-3.5 μ.

Fructifications numerous, appearing as black rounded and somewhat elevated dots, 200-350 μ in diameter, formed on the upper surface of the leaf in the irregularly circular, discolored areas which are 0.3-2 cm. in diameter. The clypeus is black, amphigenous or occasionally only epigenous, irregularly developed and variable in size, 72-285 μ in diameter, 10-72 μ thick, the dorsal clypeus ostiolate. The locules, formed in the mesophyll of the leaf, are sub-

[1]ZAHLBRUCKNER, A. Catalogus Lichenum Universalis. vol. 1-9: 1922-33. Borntraeger, Leipzig.

globose to depressed globose, rarely more than one in a stroma, 243-360 μ in diameter, 126-255 μ high, with slender hyaline or subhyaline walls. The asci are broadly clavate, 72-100 × 19.5-31 μ, 8-spored. The ascospores are irregularly distichous, hyaline, smooth, broadly ellipsoid, both ends bluntly rounded, 19.5-25.5 × (12.5)-14.5-16.5 μ. Paraphyses hyaline, 72-90 × 2.5-3.5 μ, straight or flexuous, simple or occasionally branched below.

On *Buddleia Humboldtiana* Roem. & Schult., Valley of Mexico, Mexico, Oct. 3, 1895, *Pringle*.

Accompanying *Phyllachora Buddleiae* and within the same discolored area, the conidial stage is frequently found. To this the writer gives the name *Phleospora Buddleiae* in the belief that, wherever possible, the conidial stages should also be recorded in order that at some future date they may serve as definite characters for the natural arrangement of the ascigerous phase.

Phleospora Buddleiae Linder, sp. nov.

Acervulis (pycnidiis?) socio *Phyllachora Buddleiae* Arn., solitariis, paucis, epigenis, subepidermicis, 228-342 × 110-135 μ, pariete superne tantum e contextu mutatis matricis formato; hypostromate tenui, hyalino vel subhyalino; conidiophoris palisformibus parallelis, 7-8 × 1.8-3 μ simplicibus vel breve-ramosis, 1-3-septatis, cellula terminali in denticulum cylindricum rotundato-fastigata; conidiis 9-11 × 0.5-1 μ, hyalinis, cylindricis vel leniter fastigatis, 1-septatis, cellulis duabus ad septum facile separantibus.

Acervuli or pseudo-pycnidia in the dead areas in association with *Phyllochora Buddleiae* Arn., few, solitary, epigenous, subepidermal but later erumpent; the upper part of the pseudo-pycnidium is composed of discolored host cells which form the clypeus; the thin hypostroma is hyaline or subhyaline. The conidiophores are closely arranged in a palisade-like layer and are simple or short-branched, 7-8 × 1.8-3 μ, 1-3-septate, the terminal cell tapering to an elongate sporogenous tooth. The conidia are hyaline, cylindric or tapering, 9-11 × 0.5-1 μ, 1-septate, the cells readily breaking apart at the septum.

The specimen of *Gymnosporangium Ellisii* (Berk.) Farlow *I* (no. 675) is of interest in that it demonstrates that Professor Thaxter, to the very end of his career, maintained his interest in the genus of rusts to which this species belongs. The specimens issued under no. 675 are the results of inoculation experiments made by Professor Thaxter

at his summer home at Kittery Point, Maine, with teleutospores obtained by him from Portsmouth, New Hampshire.

A word should also be said in explanation of the inclusion of the common *Lycoperdon piriforme* Schaeff. Although the specimen was determined by the late C. G. Lloyd, Dr. Thaxter made a notation to the effect that it seemed to be *L. coloratum*. Which determination is correct, or whether *L. coloratum* is a valid species, the writer does not feel qualified to state. It is hoped, however, that by calling attention to this point, some student of the group will be enticed to solve the problem.

The task of sorting, preparing, and labeling the specimens of this century of the Reliquiae Farlowianae has been carried out by Mrs. L. W. Riddle, while the checking of names and authorities has been done by Dr. Grant D. Darker. To both of these members of the Farlow Herbarium staff, the Herbarium is greatly indebted.

PLATE 109

All drawings are made with the aid of the camera lucida at the approximate magnifications indicated below.

Fig. 1. Photograph to show a typical diseased area with the numerous more or less concentrically arranged fruiting bodies.

Fig. 2. Ascus to show partially distichous arrangement of the 8 broadly ellipsoid ascospores. × 1000.

Fig. 3. A single conidiophore with a slender elongation on which is borne a conidium. × 2230.

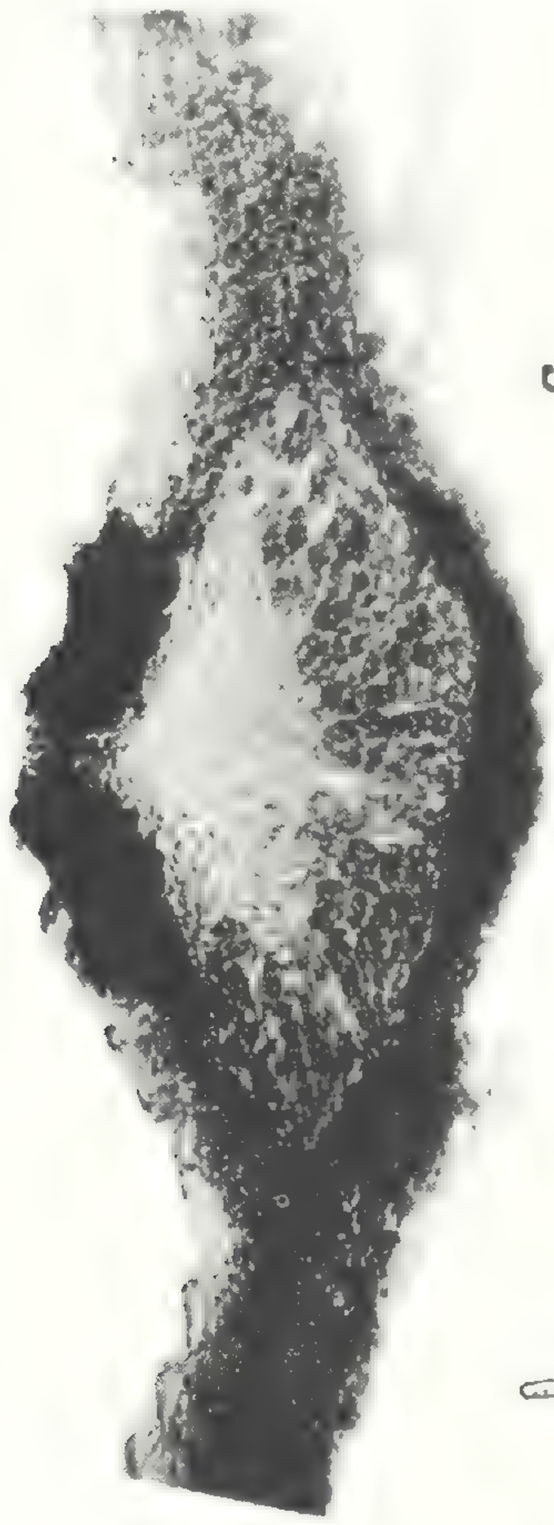
Fig. 4. Conidia showing the broad central septum at which the two cells break apart. Two of the conidia are unbroken. × 2230.

Fig. 5. A group of conidiophores from the closely packed palisade-like sporogenous layer. × 1000.

Fig. 6. Section through a fruiting body imbedded in leaf tissue, to show the upper and lower clypeus, the ostiole, the arrangement of the asci, and the numerous filiform paraphyses. × 130.

Fig. 7. Section through an "acervulus" to show the ruptured "clypeus" which consists for the most part of discolored epidermal tissue. × 130.

FARLOW HERBARIUM,
HARVARD UNIVERSITY.



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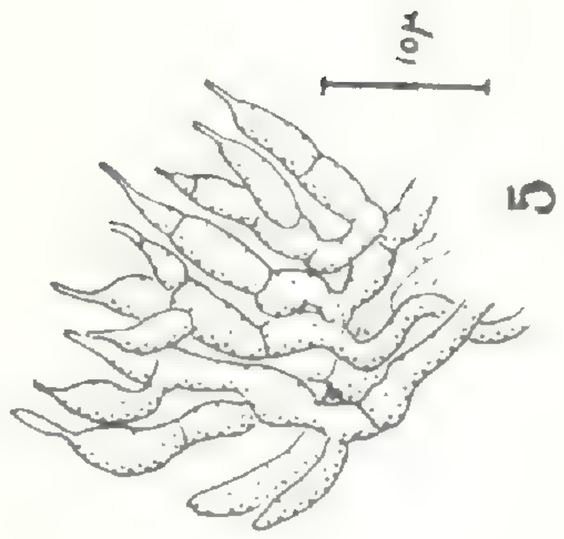

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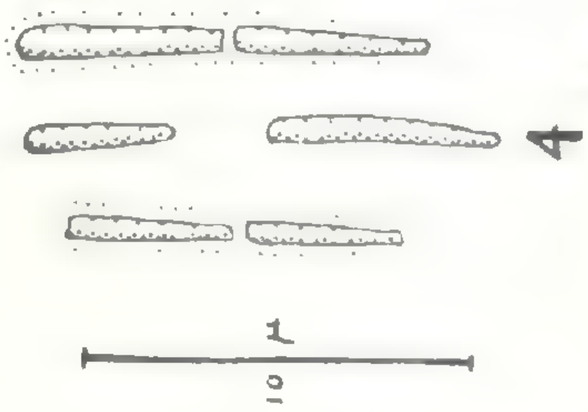

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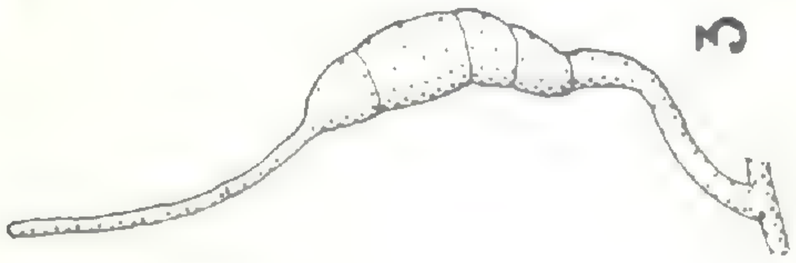

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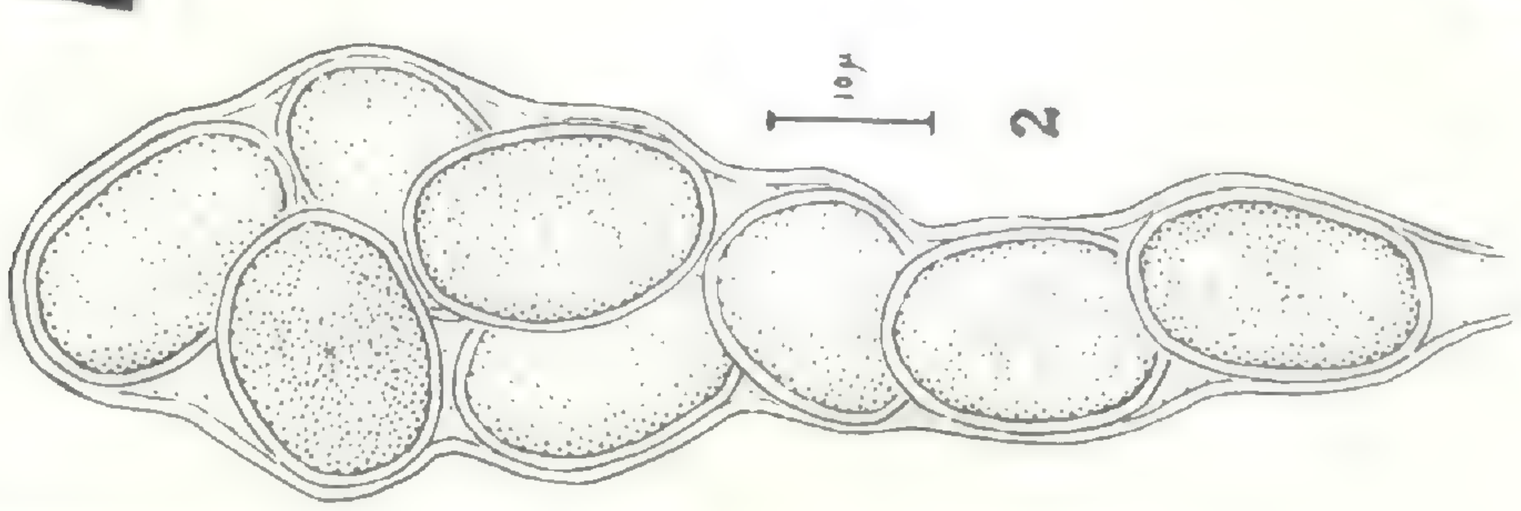

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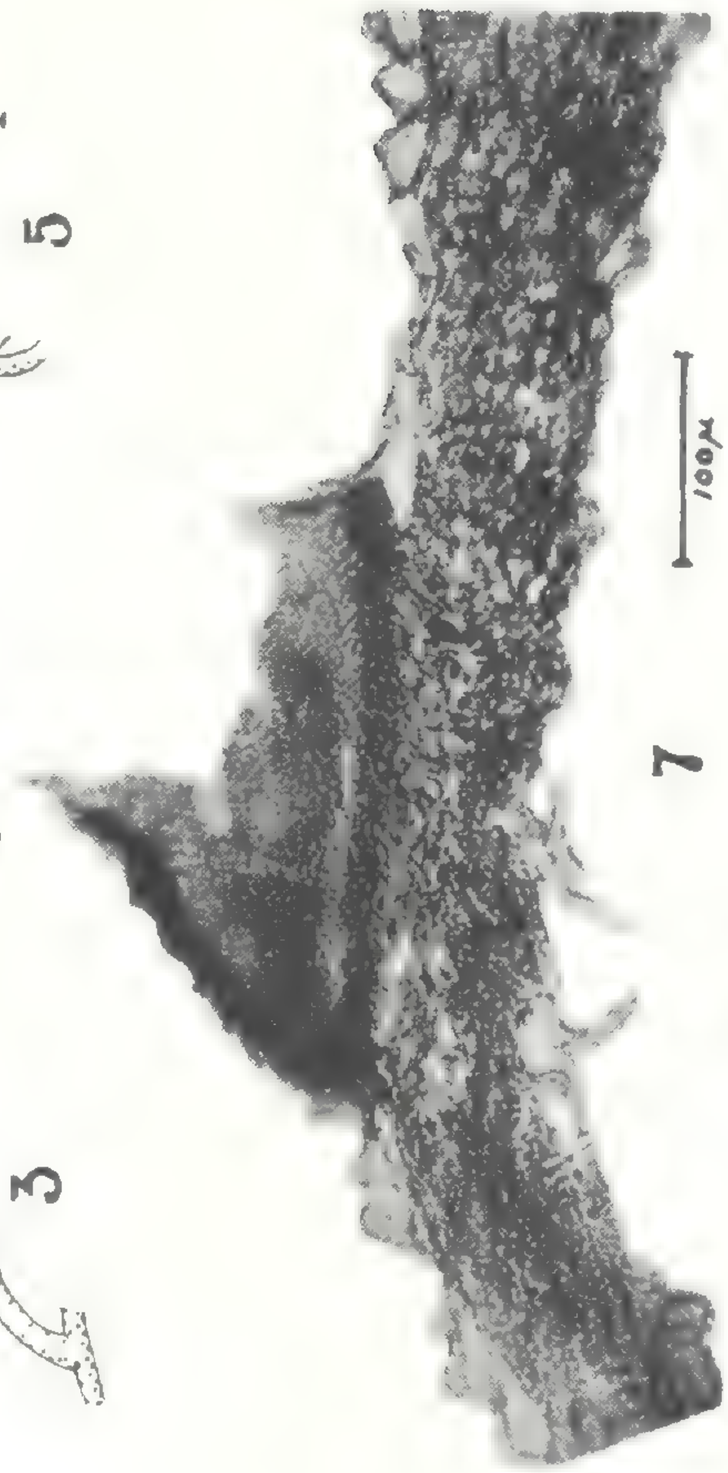

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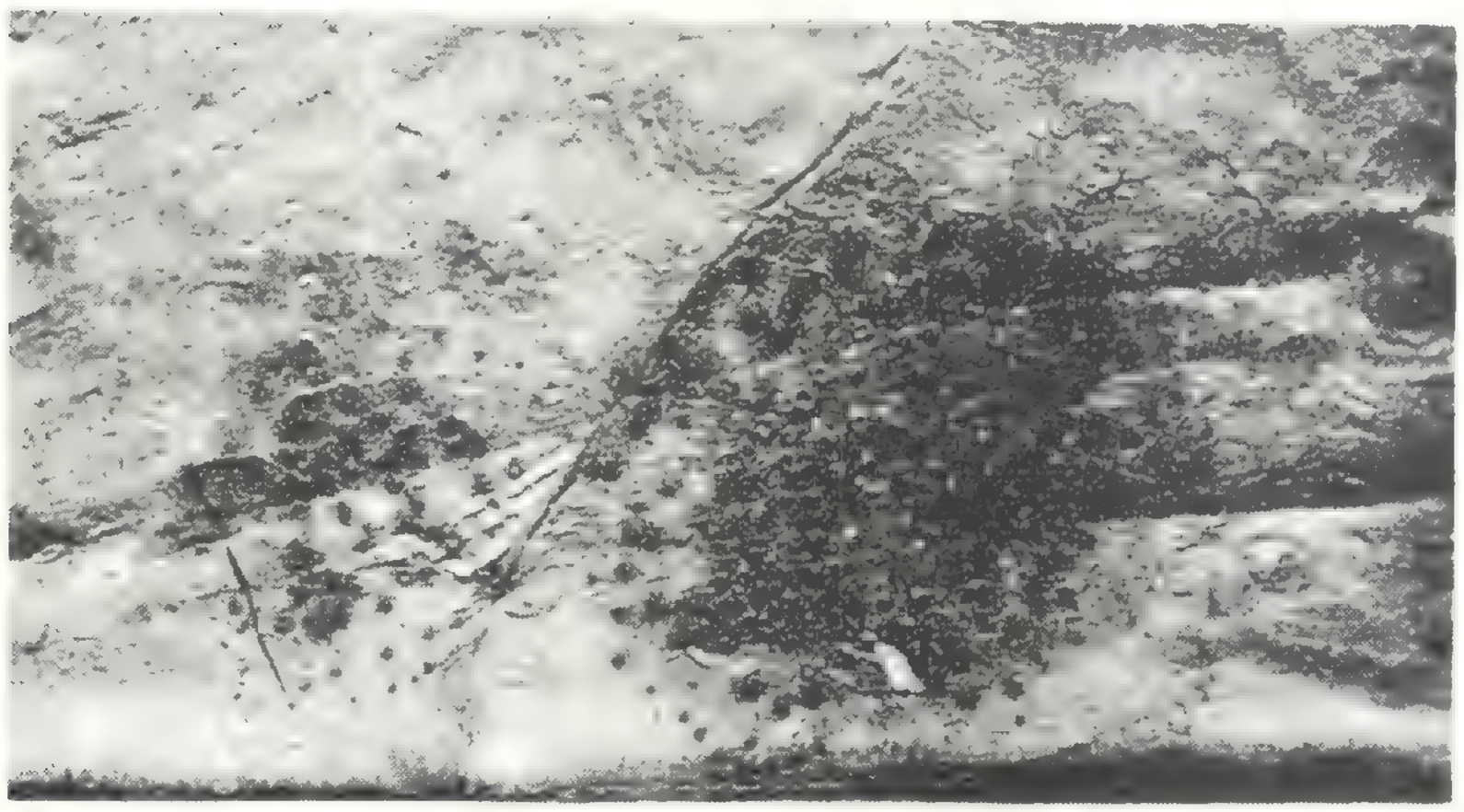

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PHYLLACHORA BUDDLEIAE ARNAUD

NOMENCLATURAL PRIORITY IN THE UREDINALES[1]

J. C. Arthur

In formulating the International Rules of Botanical Nomenclature,[2] which were the result of deliberations at the Botanical Congress of 1905 and 1910, the year 1753 was selected for the beginning of nomenclature for the various classes of plants, with a few exceptions, among them being that of the Uredinales (see Art. 19). The attempt to exclude from recognition in each group all names antedating the earliest important general treatise using binomial nomenclature led to the selection of Persoon's Synopsis Methodica Fungorum of 1801 as a starting point for the rusts and some other fungi.

As the Rules are formulated with the avowed purpose of promoting so far as possible uniform procedure in the use of botanical names it is pertinent to inquire if the exception for the starting point for the Uredinales was well selected and whether it meets that end. The question at issue is not one of theory, sentiment or individual preference, but one of facts which can be demonstrated by statistics. If the valid species of rusts established in the forty-eight years between 1753 and 1801 tend to disturb the uniform usage of subsequent years the exception to the general Rule is justified. On the contrary, if the exception introduces disturbance or uncertainty in subsequent usage, the exception should be cancelled. To understand the situation it is well to review the establishment of genera and species antedating Persoon's publication of 1801.

The only genera of the Uredinales proposed during that period were *Aecidium,* 1791, and *Uredo* and *Puccinia,* 1794, each erected by Persoon. As these genera were recognized in the Synopsis of 1801 which one of the alternate dates is accepted for their establishment is immaterial. Before these dates species of rusts had been referred to *Tremella, Lycoperdon* and *Ascophora,* all non-rust genera.

During this interval of forty-eight years between 1753 and 1801 a comparatively small number of rust species were described. If we exclude names applied to aecidial stages, as the International Rules require, and all duplicated names and synonyms, there are left to be

[1]Contribution from the Department of Botany, Purdue University Experiment Station.

[2]Briquet, John. Règles Internationales de la Nomenclature Botanique, 110 pp., June, 1912.

considered in this connection only twenty-six names by six authors, viz.: Linnaeus (1753), Dickson (1785), Jacquin (1788), Schrank (1789), Tode (1790) and Persoon (1791-99). The majority of these twenty-six names were accepted by Persoon in his Synopsis without change, except to transfer to the genus *Uredo* such as were formerly in *Lycoperdon* and *Aecidium*.

Out of this list of twenty-six names, published prior to 1801, only the following residue of eight names that were not transferred to the Synopsis without change would be affected by an earlier date for the beginning of priority, all being founded, irrespective of generic assignment, upon the "perfect state," and all but one (*Uredo Helioscopiae*) on the teleutosporic form.

Antedating 1801		Synopsis, 1801
Aecidium fuscum Pers.	changed to	Aecidium Anemones Pers.
Tremella Sabinae Dicks.	" "	Puccinia Juniperi Pers.
Ascophora disciflora α Tode	" " "	mucronata Pers.
Puccinia Polygoni Pers.	" " "	Polygoni-Aviculariae Pers.
Lycoperdon caryophyllinum Schr.	" "	Uredo Dianthi Pers.
Uredo Helioscopiae Pers.	" " "	Euphorbiae-Helioscopiae Pers.
Uredo Fabae Pers.	" " "	Viciae-Fabae Pers.
Uredo appendiculata β Pisi Pers.	" " "	appendiculata β Pisisativae Pers.

To justify the acceptance of 1801 for the beginning of rust nomenclature it must be shown that the eight names in the column for 1801 have been used by the majority of systematic uredinologists in preference to those antedating 1801. A search of the literature shows, however, that for more than a hundred years six out of the eight names were either not used at all, or only by one or two authors. *Uredo Dianthi* Pers. had been accepted by a few authors, while the one name receiving the greatest favor was that of *Puccinia mucronata* Pers., which was used by Strauss, 1810, Fries, 1815, Martius, 1817, Schlechtendahl, 1824, and some later authors, but since 1895 has been generally dropped in recognition of the earlier name. On the whole the usage up to the promulgation of the International Rules has been overwhelmingly in support of the names antedating 1801.

The usage of authors in general certainly shows no decided preference for the eight names of 1801 over the names previously established. For weightier evidence regarding the unbiased recognition of the earli-

est names that should be accepted it is best to turn to the more recent standard systematic works by authors of recognized ability, who had the facilities and inclination to make a careful taxonomic study. The following six standard works can be taken as a consensus of scholarly opinion regarding a suitable recognition of priority among the Uredinales.

Sydow (P. & H.), Monogr. Ured., 1902-15, use all the original eight specific names and none of 1801. The other five authors each employ all but one of the original eight specific names, and the exception is not taken from Persoon's Synopsis of 1801. They are:

Winter, Pilze Deutschl., 1881.
Fischer, Ed., Ured. der Schweiz, 1904.
Trotter, Flora Ital. Crypt., Ured., 1908-14.
Grove, British Rust Fungi, 1913.
Klebahn, Krypt.-Fl. Mark, Brandenburg, 1914.

No systematic work generally accepted as standard, which includes the eight names here considered, and which covers a wide geographical area, has been omitted from this list.

These facts undeniably show that the point of departure for nomenclature for the Uredinales in order to secure "fixity of names" and be "used by the great majority of naturalists in all countries," should be Linnaeus, Species Plantarum, 1753, and not Persoon, Synopsis Methodica Fungorum, 1801.

PURDUE UNIVERSITY,
LAFAYETTE, INDIANA.

NOTES

Trees of the Southeastern States. — From the University of North Carolina Press comes an attractive illustrated book of 399 pages on the Trees of the Southeastern States, by W. C. Coker and H. R. Totten.

The region covered, including the states of Virginia, North and South Carolina, Georgia and the northern part of Florida, is one of exceptional interest for students of trees. Some idea of the richness of its forest flora may be had from the fact, as stated in the preface to this book, that there are many more kinds of native trees in North Carolina alone than in the whole of Europe, and as examples of the large development of some of the tree genera it is interesting to note that there are 11 species of pine, 10 of hickory, 29 oaks, 9 magnolias and 13 lindens amongst the 227 native trees described.

The contents of the book include a brief introduction and key to the genera, followed by descriptions and keys to the different species, and in addition a great amount of interesting information on the local range, abundance, and economic value of the different trees, much of which is presented in an original way or is based upon the personal observations of the authors. There is also a short bibliography and glossary for the use of students.

While the treatment is scientific and follows the arrangement of other tree manuals, the language has been designedly made as simple as possible and technical terms are generally avoided or translated both in the keys and in the descriptions, so that they will be readily understood even by those who have very little botanical knowledge. The original outline drawings, showing the leaves, flowers, and fruits of the different trees add greatly to the value of the work. These are very well done, and they bring out clearly the distinctive characters of the different species.

Although designed primarily for students of botany and of forest trees in the southeastern states, and naturally of the greatest value to them, this little book cannot fail to be of interest to tree students everywhere. — ERNEST J. PALMER.

JOURNAL
OF THE
ARNOLD ARBORETUM

VOLUME XV. OCTOBER, 1934 NUMBER 4

NOTES ON THE LIGNEOUS PLANTS DESCRIBED BY LEVEILLE FROM EASTERN ASIA[1]

ALFRED REHDER

CLETHRACEAE

Clethra Bodinieri Léveillé in Fedde, Rep. Spec. Nov. x. 475 (1912); Fl. Kouy-Tchéou, 147 (1914).

CHINA. K w e i c h o u : Pin-fa, près ruisseaux, montagnes, *J. Cavalerie,* no. 510, Sept. 24, 1902 (holotype; photo. in A. A.)

This species seems closely related to *C. Fabri* Hance from which it is easily distinguished by the rather narrow remotely denticulate leaves with only 5-10 small mucro-like teeth on each side and by the very slender pedicels 6-7 mm. long. The specimen is in young fruit. Handel-Mazzetti according to a note on the type sheet refers to this species also Ching no. 5734 and 5804 which I have not seen.

Clethra Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. x. 476 (1912); Fl. Kouy-Tchéou, 147 (1914).

Clethra Esquirolii Léveillé, l. c. 475 (1912); l. c. 147 (1914).

Clethra lineata Léveillé in Fedde, Rep. Spec. Nov. XII. 534 (1913); Fl. Kouy-Tchéou 148 (1914).

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie,* no. 5 (not 35), July 10, 1902, "haut 1 - 2 mètres, fl. blanches, legèrement odorantes" (holotype of *C. Cavaleriei;* photo. in A. A.); environs de Tou-chan, *J. Cavalerie,* July 19, 1898 (syntype of *C. Esquirolii;* merotype and photo. in

[1]Continued from p. 117; for preceding parts see Vol. x. 108-132, 164-196; XII. 275-281; XIII. 229-332; XIV. 223-252; XV. 1-27.

A. A.); Hoa-ouan-jao, *J. Esquirol,* no. 651, Aug. 1905, "fl. blanche" (syntype of *C. Esquirolii;* photo. in A. A.); moulins de Tong-tchéou, *J. Esquirol,* no. 3238, July 10, 1912 (holotype of *C. lineata;* photo. in A. A.).

The specimens enumerated above are apparently all conspecific and closely related to *C. Fargesii* Franch. from which they are readily distinguished by the usually solitary raceme or occasionally with one or two additional smaller ones, and by the larger flowers with oblong-lanceolate sepals and glabrous filaments. From *C. Delavayi* Franch. and *C. monostachya* Rehd. & Wilson they differ in the glabrous style and in the petals being sparingly pilose inside.

I have adopted the name *C. Cavaleriei* for the following reasons though in the original article *C. Esquirolii* appears on the preceding page: (1) the name has been already used by Dr. Handel-Mazzetti who has distributed specimens under this name, (2) the type of *C. Cavaleriei* is a specimen in good flowering condition. Esquirol's no. 651 which must be considered, on account of the name, the type of *C. Esquirolii,* is in a rather poor condition.

Clethra Cavaleriei has been collected in Kweichou also by Handel-Mazzetti (no. 10557) and by Steward, Chiao & Cheo (no. 394).

Clethra kaipoensis Léveillé in Fedde, Rep. Spec. Nov. x. 475 (1912); Fl. Kouy-Tchéou, 147 (1914).

Clethra pinfaensis Léveillé, l. c. 476 (1912); l. c. 148 (1914).

CHINA. Kweichou: Tsin-gay (Kai-po), montagnes, *J. Cavalerie,* no. 1221, August 5, 1903 "haut 1 à 2 m., fl. blanches" (holotype of *C. kaipoensis;* photo. in A. A.); Pin-fa, *J. Cavalerie,* no. 346, Aug. 31, 1902 (holotype of *C. pinfaensis;* photo. in A. A.).

This species is apparently closely related to *C. Fargesii* Franch. but is easily distinguished by the rather shaggy and fulvous pubescence of the inflorescence, not close and whitish gray, by the short pedicels 1-3 mm. long and the short ovate-lanceolate bracts which even in the very young inflorescence do not exceed the flower-buds.

Clethra kaipoensis has been collected in Kweichou also by Handel-Mazzetti (nos. 10766 and 10997) who has distributed these numbers as *C. pinfaensis,* but as Cavalerie no. 1221 is a much better specimen and precedes *C. pinfaensis* in Léveillé's enumeration I have adopted *C. kaipoensis* as the name for this species.

RHODODENDRON L.[1]

Subgen. I. **EURHODODENDRON** Endl.

Sect. 1. LEIORHODION Rehd.

ARBOREUM Series: ARGYROPHYLLUM Subseries

Rhododendron denudatum Léveillé in Fedde, Rep. Spec. Nov. XIII. 339 (1914); Cat. Pl. Yun-Nan, 89 (1916). — Tagg in Rhodod. Soc. Notes, III. 228, 231 (1928); in Spec. Rhodod. 24 (1930).

Rhododendron xanthoneuron Léveillé in Fedde, Rep. Spec. Nov. XIII. 340 (1914); Cat. Pl. Yun-Nan, 94 (1916).

CHINA. Yunnan: rochers de Tien-sin, 3000 m., *E. E. Maire,* April 1913 (holotype of *Rh. denudatum*); mont Te-pe-lou, 3200 m., *E. E. Maire,* May 1913 (holotype of *Rh. xanthoneuron*).

Rhododendron denudatum is closely related to *Rh. floribundum* Franch. It is probably a valid species.

Rhododendron farinosum Léveillé in Fedde, Rep. Spec. Nov. XIII. 340 (1914); Cat. Pl. Yun-Nan, 90 (1916). — Tagg in Rhodod. Soc. Notes, III. 229 (1928); in Spec. Rhodod. 25 (1930).

CHINA. Yunnan: flanc du Io-chan, 3200 m., *E. E. Maire,* May 1913 (holotype).

This is almost certainly a valid species and closely related to *Rh. floribundum* Franch. and *Rh. denudatum* Lévl.

TALIENSE Series: ADENOGYNUM Subseries

Rhododendron cruentum Léveillé in Fedde, Rep. Spec. Nov. XII. 284 (1913); Cat. Pl. Yun-Nan, 89 (1916). — Tagg in Rhodod. Soc. Notes, III. 228 (1928); in Spec. Rhodod. 640 (1930).

CHINA. Yunnan: brousse du plateau de Ta-hai-tse, 3200 m., *E. E. Maire,* May 1912 (holotype).

This is closely related to *Rh. Bureavi* Franch.

LACTEUM Series

Rhododendron lacteum Franchet in Bull. Soc. Bot. France, XXXIII. 231 (1886). — Tagg in Rhodod. Soc. Notes, III. 230 (1928); in Spec. Rhodod. 381 (1930).

Rhododendron Mairei Léveillé in Fedde, Rep. Spec. Nov. XII. 285 (1913); Cat. Pl. Yun-Nan, 92 (1916).

CHINA. Yunnan: montagnes de Lai-teou-po, 3000 m., *E. E. Maire,* May 1912 (holotype of *Rh. Mairei*).

[1]The following determinations and comments (except those of the subgenus Anthodendron) on Léveillé's specimens were kindly sent me by Sir William Wright Smith, Regius Keeper of the Royal Botanic Garden of Edinburgh, who with Mr. H. F. Tagg has for years made a special study of Chinese rhododendrons.

THOMSONI Series: SOULIEI Subseries

Rhododendron Souliei Franchet in Jour. de Bot. IX. 393 (1895). — Tagg in Rhodod. Soc. Notes, III. 228 (1928); in Spec. Rhodod. 732 (1930).

Rhododendron cordatum Léveillé in Bull. Géog. Bot. XXIV. 282 (1914); Cat. Pl. Yun-Nan, 89, fig. 21 (1916).

CHINA. Yunnan: sommet du Io-chan, 3400 m., *E. E. Maire,* June 1913 (holotype of *Rh. cordatum*).

The material of *Rh. cordatum* is very fragmentary, but there is little doubt that it is *Rh. Souliei* Franch.

FORTUNEI Series: FORTUNEI Subseries

Rhododendron decorum Franchet in Bull. Soc. Bot. France, XXXIII. 230 (1886). — Tagg in Rhodod. Soc. Notes, III. 227, 229 (1928); in Spec. Rhodod. 269 (1930).

Rhododendron Franchetianum Léveillé in Bull. Soc. Agric. Sci. Arts Sarthe, XXXIX. 46 (1903); Cat. Pl. Yun-Nan, 91 (1916).

?Rhododendron albicaule Léveillé in Fedde, Rep. Spec. Nov. XIII. 148 (1914). — Tagg in Spec. Rhodod. 851 (1930).

Rhododendron Giraudiasii Léveillé in Fedde, Rep. Spec. Nov. XIII. 340 (1914).

CHINA. Kweichou: montagnes de Sin-tchen, près Hin-y-hien, *J. Cavalerie,* no. 3923, June 1912 (holotype of *Rh. albicaule*). Yunnan: rochers, mont de Siao-ou-long, 2700 m., *E. E. Maire,* June 1917 (holotype of *Rh. Giraudiasii*); environs de Yunnan-sen, sur les hautes montagnes bordant la plaine, *E. Bodinier,* Nov. 11, 1896, *F. Ducloux,* March 28, 1897 "fort arbuste de 2 m.; floraison précoce; fleurs blanches avec quelque pointillé à la partie supérieure" (syntypes of *Rh. Franchetianum*).

The material of *Rh. albicaule* in the Herbarium Léveillé is *Rh. decorum,* but Léveillé's description does not fit the specimen well. In Flore du Kouy-Tchéou, p. 152, Léveillé cites *Rh. albicaule* as a synonym of *Rh. Cavaleriei,* a species of the Stamineum Series. This is obviously an error, as the specimen under Cavalerie 3923 is *Rh. decorum.* Moreover, Léveillé's description does not fit in with a member of the Stamineum series.

FALCONERI Series

Rhododendron rex Léveillé in Fedde, Rep. Spec. Nov. XIII. 340 (1914); Cat. Pl. Yun-Nan, 93 (1910). — Tagg in Rhodod. Soc. Notes, III. 230 (1928); in Spec. Rhodod. 250 (1930).

CHINA. Yunnan: mont Io-chan, 3200 m., *E. E. Maire,* May 1913 (holotype).

Sect. 2. LEPIPHERUM G. Don

MADDENII Series: MEGACALYX Subseries

Rhododendron liliiflorum Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913); Fl. Kouy-Tchéou, 153 (1914). — Hutchinson in Notes Bot. Gard. Edinb. XII. 33, fig. 5 (1919); in Spec. Rhodod. 493 (1930). — Tagg in Rhodod. Soc. Notes, III. 229 (1928).

CHINA. K w e i c h o u : Pin-fa, Juin-ou-chan, *J. Cavalerie,* no. 54, June 3 and July 15, 1902 (syntypes).

MADDENII Series: CILIICALYX Subseries

Rhododendron Lyi Léveillé in Fedde, Rep. Spec. Nov. XIII. 147 (1914); Fl. Kouy-Tchéou, 153 (1914). — Hutchinson in Notes Bot. Gard. Edinb. XII. 33 (1919); in Spec. Rhodod. 467 (1930). — Tagg in Rhodod. Soc. Notes, III. 230 (1928).

CHINA. K w e i c h o u : Gan-chouen, *J. Cavalerie,* no. 3883, April 1912 (holotype).

Rhododendron missioniarium Léveillé in Bull. Géog. Bot. XXV. 20 (1915); Cat. Pl. Yun-Nan, 92 (1916). — Hutchinson in Not. Bot. Gard. Edinb. XII. 55 (1919); in Spec. Rhodod. 468 (1930). — Tagg in Rhodod. Soc. Notes, III. 230 (1928).

CHINA. Y u n n a n : rochers de Tong-koua-pin, 3000 m., *E. E. Maire,* April 1912 (holotype).

HELIOLEPIS Series

Rhododendron Leclerei in Fedde, Rep. Spec. Nov. XII. 284 (1913); Cat. Pl. Yun-Nan, 92 (1916). — Tagg in Rhodod. Soc. Notes, III. 229 (1928). — Hutchinson in Spec. Rhodod. 326 (1930).

CHINA. Y u n n a n : haut plateau de Ta-hai-tse, 3200 m., *E. E. Maire,* May 1912 (holotype).

TRIFLORUM Series: TRIFLORUM Subseries

Rhododendron lutescens Franchet in Bull. Soc. Bot. France, XXXIII. 235 (1886). — Hutchinson in Bot. Mag. CXLVI. t. 8851 (1920); in Spec. Rhodod. 789 (1930). — Tagg in Rhodod. Soc. Notes, III. 228, 229 (1928).

Rhododendron Lemeei Léveillé in Fedde, Rep. Spec. Nov. XIII. 339 (1913); Cat. Pl. Yun-Nan, 92 (1916).

Rhododendron Blinii Léveillé in Bull. Géog. Bot. XXV. 21 (1915); Cat. Pl. Yun-Nan, 88 (1916).

CHINA. Y u n n a n : monts de Ta-tchai, 3000 m., *E. E. Maire,* April 1913 (holotype of *Rh. Lemeei*); brousse de coteaux à Tchen-fong-tchan, 550 m., *E. E. Maire,* May 1912 (holotype of *Rh. Blinii*).

Rhododendron Lemeei and *Rh. Blinii* were first identified with *Rh. rubiginosum* by H. F. Tagg (l. c.).

TRIFLORUM Series: YUNNANENSE Subseries

Rhododendron tatsienense Franchet in Jour. de Bot. IX. 394 (1895). — Tagg in Rhodod. Soc. Notes, III. 230 (1928); in Spec. Rhodod. 853 (1930). — Hutchinson in Spec. Rhodod. 812 (1930).

Rhododendron tapelouense Léveillé in Bull. Géog. Bot. XXV. 20 (1915); Cat. Pl. Yun-Nan, 93 (1916).

CHINA. Yunnan: mont Ta-pé-lou, 3200 m., *E. E. Maire*, May 1912 (holotype of *Rh. tapelouense*).

Rhododendron tapelouense was first identified with *Rh. tatsienense* by Tagg (l. c.).

Rhododendron siderophyllum Franchet in Jour. de Bot. XII. 262 (1898). — Tagg in Rhodod. Soc. Notes, III. 229 (1928); in Spec. Rhodod. 852 (1928). — Hutchinson in Spec. Rhodod. 809 (1930).

Rhododendron Jahandiezii Léveillé in Fedde, Rep. Spec. Nov. XIII. 340 (1914); Cat. Pl. Yun-Nan, 92 (1916).

CHINA. Yunnan: flanc du Io-chan, 3200 m., *E. E. Maire*, May 1913 (holotype of *Rh. Jahandiezii*).

Rhododendron leucandrum Léveillé in Fedde, Rep. Spec. Nov. XII. 103 (1913); Fl. Kouy-Tchéou, 153 (1914). — Tagg in Rhodod. Soc. Notes, III. 229 (1928); in Spec. Rhodod. 852 (1930).

CHINA. Kweichou: Kiao-tche-che, *J. Cavalerie*, no. 1254, April 10, 1902 (holotype).

Rhododendron leucandrum is referred doubtfully to *Rh. siderophyllum* in Species of Rhododendron (l. c.), but it has an unusually elongated calyx and the lepidote scales are not the same in the two species. It is not exactly equivalent to any described species of the Triflorum Series and may stand till further material is available. It is founded on Cavalerie no. 1254 which is a mixed gathering; part of the material is named *Rh. Seguini* which is *Rh. Bodinieri*, but the remaining part is no doubt what Léveillé intended as *Rh. leucandrum*.

Rhododendron Bodinieri Franchet in Jour. de Bot. XII. 257 (1898). — Tagg in Rhodod. Soc. Notes, III. 230 (1928). — Hutchinson in Spec. Rhodod. 794 (1930).

Rhododendron rubro punctatum Léveillé & Vaniot in Fedde, Rep. Spec. Nov. IX. 448 (1911); Fl. Kouy-Tchéou, 153 (1914).

Rhododendron Seguini Léveillé in Fedde, Rep. Spec. Nov. XIII. 148 (1914).

CHINA. Kweichou: Pin-fa, mont du Ouang-tse, *J. Cavalerie*, Sept. 1908 (holotype of *Rh. rubro-punctatum*); Kiao-tche-tche et Ganchouen, *J. Cavalerie*, no. 1254, April 10, 1902 (holotype of *Rh. Seguini*).

Rhododendron Seguini was referred to *Rh. rubro-punctatum* by Léveillé in his Flore du Kouy-Tchéou and both species were identified by Tagg (l. c.) with *Rh. Bodinieri*.

Rhododendron caeruleum Léveillé in Fedde, Rep. Spec. Nov. XII. 284 (1913); Cat. Pl. Yun-Nan, 89 (1916); Cat. Ill. Seu-Tchouen, pl. 25 (1918) MS. — Tagg in Rhodod. Soc. Notes, III. 228 (1928).

Rhododendron rarosquameum Balfour f. in Notes Bot. Gard. Edinb. X. 137 (1917).

Rhododendron eriandrum Léveillé apud Hutchinson in Spec. Rhodod. 798, 851 (1930).

CHINA. Yunnan: mont de Mo-tsou (fleuve Bleu), *E. E. Maire*, May 1912 (holotype of *Rh. caeruleum*); Niou-ko-tien-tien, *E. E. Maire*, May, 1911, "c. 60 cm. — 1 m., fl. violettes" (holotype of *Rh. eriandrum*).

In Species of Rhododendron *Rh. eriandrum* Lévl., a name appearing in Léveillé's handwriting on the specimen cited above, but remaining apparently unpublished, has been taken up as the valid name for this species, and *Rh. caeruleum* Lévl. referred to it as a doubtful synonym, but *Rh. caeruleum* is clearly the oldest name and doubtless identical with *Rh. rarosquameum* and *Rh. eriandrum*. The type of *Rh. caeruleum* is cited among the syntypes of *Rh. rarosquameum*.

LAPPONICUM Series

Rhododendron polycladum Franchet in Bull. Soc. Bot. France, XXXIII. 234 (1886). — Tagg in Rhodod. Soc. Notes, III. 230 (1928). — Hutchinson in Spec. Rhodod. 421, 853 (1930).

Rhododendron nanum Léveillé in Fedde, Rep. Spec. Nov. XII. 285 (1913); Cat. Pl. Yun-Nan, 92 (1916).

CHINA. Yunnan: haut plateau de Ta-hai-tse, 3200 m., *E. E. Maire*, May 1912 (holotype of *Rh. nanum*).

Rhododendron nanum was first referred to *Rh. polycladum* Franch. by Tagg (l. c.).

VACCINIOIDES Series

Rhododendron euonymifolium Léveillé in Fedde, Rep. Spec. Nov. XII. 103 (1913); Fl. Kouy-Tchéou, 152 (1914). — Tagg in Rhodod. Soc. Notes, III. 228 (1928). — Hutchinson in Spec. Rhodod. 820 (1930).

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 242, Aug. 21, 1902 (syntype); Hoa-ouay-jao, *J. Esquirol*, no. 661, Aug. 1905 (syntype).

This is apparently a valid species.

SCABRIFOLIUM Series

Rhododendron spinuliferum Franchet in Jour. de Bot. IX. 399

(1895). — Craib in Bot. Mag. CXXXVII. t. 8408 (1911). — Tagg in Rhodod. Soc. Notes, III. 229 (1928). — Hutchinson in Spec. Rhodod. 606, 852 (1930).

Rhododendron Duclouxii Léveillé in Bull. Soc. Agric. Sci. Sarthe, XXXIX. 46 (1903); Cat. Pl. Yun-Nan, 90 (1916).

Rhododendron fuchsiaeflora Léveillé in Fedde, Rep. Spec. Nov. XII. 284 (1913); Cat. Pl. Yun-Nan, 91 (1916), "*fuchsiiflora*." — Tagg in Rhodod. Soc. Notes, III. 229 (1928), "*fuchsiaeflorum*," pro synon.

CHINA. Yunnan: environs de Yun-nan-sen, bois de la pagode de Kiong-tchou-se et de celle de Hé-long-tan, *E. Bodinier*, no. 115, Feb. 24 and March 2, 1897 "petit arbuste, fleurs pourpres" (syntypes of *Rh. Duclouxii*); Yun-nan-sen, c. dans la montagne près du College, *F. Ducloux*, no. 61, "petit arbuste à fleurs rose-pourpres, premières fleurs 29 janv. 1897" (syntype of *Rh. Duclouxii*); montagnes arides de Motsou (fleuve Bleu), 800 m., *E. E. Maire*, May 1912 (holotype of *Rh. fuchsiaeflora*).

Rhododendron fuchsiaeflora was first identified with *Rh. spinuliferum* in Species of Rhododendron (p. 852). Also *Rh. Duclouxii* was referred as a synonym to that species by Hutchinson (op. cit. p. 606), but according to Handel-Mazzetti (in litt.) it represents a hybrid between *Rh. spiciferum* Franch. and *Rh. spinuliferum* Franch. which he states is not rare around Yunnanfu. Handel-Mazzetti saw a type specimen of *Rh. Duclouxii* in the Berlin Herbarium, which was recognized also by Diels as the hybrid indicated. It may be doubted, if all the syntypes cited above represent this hybrid, and therefore, for the present *Rh. Duclouxii* is kept as a synonym of *Rh. spinuliferum* Franch., until the material in Edinburgh has been revised.

Sect. 3. RHODORASTRUM Maxim.

VIRGATUM Series

Rhododendron racemosum Franchet in Bull. Soc. Bot. France, XXXIII. 235 (1886). — Hooker f. in Bot. Mag. XXIX. t. 7301 (1893). — Tagg in Rhodod. Soc. Notes, III. 228, 230 (1928). — Hutchinson in Spec. Rhodod. 829, 852, 853 (1930).

Rhododendron motsouense Léveillé in Fedde, Rep. Spec. Nov. XIII. 148 (1914) "motsonense"; Cat. Pl. Yun-Nan, 92 (1916).

Rhododendron crenatum Léveillé in Bull. Géog. Bot. XXV. 20 (1915); Cat. Pl. Yun-Nan, 89, fig. 22 (1916).

CHINA. Yunnan: montagnes aux environs de Mo-tsou (fleuve Bleu), 800 m., Ta-hai-tse, 3200 m., *E. E. Maire*, 1911-1912 (syntypes of *Rh. motsuense*); monts derrière Mo-tsou, 3000 m., *E. E. Maire*, April 1911 (holotype of *Rh. crenatum*).

Rhododendron motsouense and *Rh. crenatum* were first referred to *Rh. racemosum* by Tagg (l. c.).

DAURICUM Series

Rhododendron mucronulatum Turczaninow in Bull. Soc. Nat. Moscow, x. no. 7, p. 155 (1837). — Nakai, Pl. Sylv. Kor. VIII. 35, t. 10 (1919).

Rhododendron dauricum L. var. *mucronulatum* (Turcz.) Maximowicz in Mém. Acad. Sci. St. Pétersb. sér. 7, XVI. no. 9, p. 44 (Rhod. As. Or.) (1870). — Tagg in Rhodod. Soc. Notes, III. 231 (1928); in Spec. Rhodod. 853 (1930).

Rhododendron Taquetii Léveillé in Fedde, Rep. Spec. Nov. XII. 101 (1913).

KOREA. Quelpaert: Hallaisan, *E. Taquet*, no. 5788, June 1911 (holotype of *Rh. Taquetii*).

Rhododendron Taquetii was first referred to *Rh. mucronulatum* by Nakai (l. c.).

Subgen. II. **AZALEASTRUM** Planch.

Sect. 1. EUAZALEASTRUM Wils.

OVATUM Series

Rhododendron Bachii Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913); Fl. Kouy-Tchéou, 152 (1914). — Tagg in Rhodod. Soc. Notes, III. 227 (1928). — Hutchinson in Spec. Rhodod. 561 (1930).

CHINA. Kweichou: Lou-mong-touan, RR., *J. Cavalerie*, no. 2982, May 1908 (holotype).

This is apparently a valid species and closely related to *Rh. ovatum* Maxim. and *Rh. leptothrium* Balf. f. & Forr.

Sect. 2. CHIONASTRUM Franch.

STAMINEUM Series

Rhododendron stamineum Franchet in Bull. Soc. Bot. France, XXXIII. 236 (1886). — Hutchinson in Bot. Mag. CXLI. t. 8601 (1915); in Spec. Rhodod. 623 (1930).

Rhododendron Cavalerici var. *Chaffanjoni* Léveillé in Bull. Soc. Agric. Sci. Sarthe, XXXIX. 49 (1903); Fl. Kouy-Tchéou, 152 (1914).

Rhododendron Chaffanjonii Léveillé ex Hutchinson in Spec. Rhodod. 623 (1930), pro synon. *Rh. staminei.*

CHINA. Kweichou: environs de Kouy-yang, mont du Collège, *J. Chaffanjon* in Hb. *Bodinier*, no. 2332, April 1898 (holotype of *Rh. Cavaleriei* var. *Chaffanjoni*).

Rhododendron Cavaleriei var. *Chaffanjoni* was first identified with *Rh. stamineum* by Hutchinson in 1930 (l. c.), but he cited it as *Rh. Chaffanjonii.*

Rhododendron Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913). — Tagg in Rhodod. Soc. Notes, III. 228 (1928). — Hutchinson in Spec. Rhodod. 614 (1930).

CHINA. K w e i c h o u : hautes montagnes, *J. Cavalerie,* no. 2375, and *J. Esquirol,* no. 476, June 1905 (syntypes).

Rhododendron Cavaleriei Léveillé in Bull. Soc. Agric. Sci. Sarthe. XXXIX. 48 (1903); Fl. Kouy-Tchéou, 152 (1914). — Tagg in Rhodod. Soc. Notes, III. 228 (1928). — Hutchinson in Spec. Rhodod. 612 (1930).

?*Reevesia Esquirolii* Léveillé in Fedde, Rep. Spec. Nov. XIII. 175 (1914); Fl. Kouy-Tchéou, 405 (1915).

CHINA. K w e i c h o u : sous-prefecture de Tou-chan, *J. Cavalerie,* no. 2633, May 1899 (holotype of *Rh. Cavaleriei*); bois de Bangnin, *J. Esquirol,* no. 2604, Feb. 29, 1912 (holotype of *Reevesia Esquirolii*).

Dr. J. M. Cowan states in a letter of April 24, 1934, that Esquirol no. 2604 is probably identical with *Rh. Cavaleriei,* but the material is poor.

Reevesia Esquirolii is enumerated by J. Anthony in his paper, "The genus Reevesia Lindl." (in Notes Bot. Gard. Edinb. xv. 121-129, 1926) as an excluded species representing a species of *Rhododendron* of the Stamineum section.

Subgen. III. **ANTHODENDRON** Endl.

Sect. TSUTSUTSI

(AZALEA Series: OBTUSUM Subseries)

Rhododendron chrysocalyx Léveillé & Vaniot in Fedde, Rep. Spec. Nov. II. 113 (1906); Fl. Kouy-Tchéou, 152 (1914). — Wilson in Jour. Arnold Arb. VI. 200 (1925). — Tagg in Rhodod. Soc. Notes, III. 228 (1928).

Rhododendron spinigerum Léveillé in Bull. Géog. Bot. XXIV. 251 (1914).

CHINA. K w e i c h o u : route de Mou-you-se à Tcheu-lin, *J. Cavalerie,* no. 2059, June 1904 (syntype of *Rh. chrysocalyx*); Pin-fa, bord des ruisseaux, *J. Cavalerie,* no. 1796, April 25, 1904 (syntype of *Rh. chrysocalyx*); ilêt à Pia-ouay-ho, 700 m., *J. Esquirol,* no. 3560, May 2, 1912 (holotype of *Rh. spinigerum*).

Rhododendron spinigerum was referred to *Rh. chrysocalyx* as a synonym by Léveillé in his Flore du Kouy-Tchéou.

Rhododendron fuchsiifolium Léveillé in Fedde, Rep. Spec. Nov. XIII. 148 (1914); Fl. Kouy-Tchéou, 152 (1914); "*fuchsiifolia*". — Tagg in Rhodod. Soc. Notes, III. 229 (1928); in Spec. Rhodod. 852 (1930).

China. Kweichou: Pin-fa, *J. Cavalerie*, no. 3221, May 20, 1907 "fl. blanc-rose, piquetées de pourpre" (holotype; photo. in A. A.).

This species is closely related to *Rh. microphytum* Franch., but differs in the corolla having outside 5 rows of stipitate glands extending from the base to about the middle of the lobes, while in *Rh. microphyton* the corolla is perfectly glabrous outside. The leaves are elliptic-ovate, acute or acuminate, rather densely strigose above, below only with flattened strigose hairs on the midrib, otherwise glabrous; in *Rh. microphyton* there are scattered red-brown hairs on the whole underside, rarely it is nearly glabrous, and the shape and size of the leaves is exceedingly variable, sometimes even broadest above the middle and obtusish.—A. R.

Rhododendron umbelliferum Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913); Fl. Kouy-Tchéou, 153 (1914); Cat. Pl. Yun-Nan, 94 (1916). — Tagg in Rhodod. Soc. Notes, III. 231 (1928); in Spec. Rhodod. 853 (1930).

China. Kweichou: Pin-fa, *J. Cavalerie*, no. 10, Apr. 2, 1902 (holotype, ex Léveillé; isotype in Hb. Léveillé and photo. of isotype in A. A.).

Of this species I have not seen the original specimen. The specimen from the Herbarium Léveillé before me is apparently a duplicate of Cavalerie no. 10 received from Kew with a copied label. This specimen consists of two branches; the larger one is *Rh. Mariesii* Hemsl., while the smaller branch seems to agree with Léveillé's rather poor description of *Rh. umbelliferum*. I am not able to refer this specimen to any described species; it seems nearest to *Rh. microphyton* Franch., but the corolla-tube is much shorter than the oblong lobes and in the two flowers examined I counted 7 stamens shorter than the lobes.—A. R.

Rhododendron yedoense Maxim. var. **poukhanense** (Lévl.) Nakai in Tokyo Bot. Mag. XXXIV. (274) (1920). — Rehder in Spec. Rhodod. 109 (1930).

Rhododendron poukhanense Léveillé in Fedde, Rep. Spec. Nov. V. 100 (1908). — Nakai, Fl. Sylv. Kor. VIII. 47, t. 18 (1919). — Tagg in Rhodod. Soc. Notes, III. 229 (1928).

Rhododendron hallaisanense Léveillé in Fedde, Rep. Spec. Nov. XII. 101 (1913).

Korea. Keiki Prov.: in arce Pouk-han, *U. Faurie*, June 3, 1901 (holotype of *Rh. poukhanense*). Quelpaert: Hallaisan, 1800 m., *E. Taquet*, no. 305, Oct. 1907 (holotype of *Rh. hallaisanense*).

Rhododendron hallaisanense was first identified with *Rh. poukhanense* by Nakai in 1919 (l. c.).

Rhododendron mucronatum (Bl.) G. Don, Gen. Syst. III. 846 (1834). — Tagg in Spec. Rhodod. 851 (1930).

Rhododendron Argyi Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913); in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 550 (Cat. Pl. Kiang-Sou, 10) (1916).

CHINA. Kiangsu: Long-se, Long-chien, Vou-sée, *Ch. d'Argy*, Apr. 20 [1861-74] (holotype of *Rh. Argyi*).

Rhododendron Argyi was first identified with *Rh. mucronatum* in 1920 by E. H. Wilson in Léveillé's herbarium, but in 1925 (Jour. Arnold Arb. VI. 174) he published it as a synonym of *Rh. dauricum* var. *mucronulatum;* this mistake was apparently brought about by the similarity in the name and the misreading of the notes he made in Edinburgh.

SPECIES DUBIAE

Rhododendron Feddei Léveillé in Fedde, Rep. Spec. Nov. XII. 102 (1913); Fl. Kouy-Tchéou, 152 (1914). — Tagg in Rhodod. Soc. Notes, III. 229 (1928); Hutchinson in Spec. Rhodod. 611 (1930).

CHINA. Kweichou: Pin-fa, précipices, *J. Cavalerie*, no. 1074, June 18, 1903, "arbrisseau 3-4 m." (holotype).

Rhododendron Feddei is probably equivalent to one of the described species of the Stamineum Series, but the material is too imperfect for determination and the name should be ignored.

Rhododendron Maximowiczianum Léveillé in Bull. Soc. Agric. Sci. Sarthe, XXXIX. 47 (1903) Cat. Pl. Yun-Nan, 92 (1916). — Tagg in Spec. Rhodod. 852 (1930).

CHINA. Yunnan: environs de Yunnan-sen, acheté à marché de la ville, apporté des montagnes voisines, *E. Bodinier*, March 20, 1897 "arbuste" (holotype).

This is said by the author to be near *Rh. siderophyllum* Franch., but the fragmentary specimens are those of a member of the Irroratum Series. The indumentum described by the author is not present in the specimens presumed to be the originals. The species should most fittingly be ignored.

Enkianthus Dunnii Léveillé in Fedde, Rep. Spec. Nov. IX. 448 (1911); Fl. Kouy-Tchéou, 148 (1914). — Hutchinson in Notes Bot. Gard. Edinb. XI. 167 (1919).

Enkianthus Cavalerici Léveillé in Fedde, Rep. Spec. Nov. IX. 448 (1911). — **Synon. nov.**

?Enkianthus xanthoxantha Léveillé in Fedde, Rep. Spec. Nov. IX. 448 (1911) "xantoxantha"; Fl. Kouy-Tchéou, 148 (1914). — **Synon. nov.**

China. Kweichou: Pin-fa, *J. Cavalerie,* no. 2300, Apr. 13, 1905 (holotype of *E. Dunnii;* photo. in A. A.); Pin-fa, sommet rocheux des montagnes, *J. Cavalerie,* no. 7, Apr. 2, 1902 (holotype of *E. Cavaleriei;* photo. in A. A.); Pin-fa, montagnes, *J. Cavalerie,* no. 930, "fleurs jaunes" (holotype of *E. xanthoxantha;* photo. in A. A.).

Enkianthus Dunnii and *E. Cavaleriei* are doubtless identical. Of *E. xanthoxantha* the collector gives the color of the flowers as yellow and if this is true it may be a distinct color-form or another species; the leaves are still undeveloped and therefore cannot be compared with those of the other specimens. *Enkianthus Dunnii* is closely related to *E. quinqueflorus* Lour. as already stated by Hutchinson (l. c.) but differs in the thinner chartaceous, not reticulate leaves, slenderer petioles, smaller flowers and lanceolate sepals. From *E. serrulatus* (Wils.) Schneid. it is easily distinguished by the not reticulate leaves with an entire cartilagineous margin, or above the middle indistinctly and remotely denticulate, as they are often in *E. quinqueflorus*. *Enkianthus Cavaleriei* is referred by Léveillé in his Flore du Kouy-Tchéou as a synonym to *E. cerasiflora,* but this is apparently a mistake, for it is quite different from that species.

Enkianthus chinensis Franchet in Jour. de Bot. IX. 371 (1895). — Léveillé, Cat. Pl. Yun-Nan, 86 (1916).

Zenobia cerasiflora Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 253 (1903).

Enkianthus cerasiflora Léveillé in Fedde, Rep. Spec. Nov. IX. 448 (1911); Fl. Kouy-Tchéou, 148 (1914). — Craib in Notes Bot. Gard. Edinb. XI. 167 (1919). — **Synon. nov.**

Bodinierella Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 101 (1913); Fl. Kouy-Tchéou, 147 (1914).

Enkianthus Leveillcanus Craib in Notes Bot. Gard. Edinb. XI. 168 (1919). — **Synon. nov.**

China. Kweichou: Tang-kio-chan, *E. Bodinier,* May 20, 1900 (holotype of *Zenobia cerasiflora;* photo. and merotype in A. A.); Pin-fa, Jouin-ou-chan, hautes montagnes, *J. Cavalerie,* no. 61, July 15, 1902 (syntype of *Bodinierella Cavaleriei;* photo. in A. A.), no. 1318, June 3, 1902, "fleurs venées, lavées de rose" (syntype of *Bodinierella Cavaleriei;* photo. in A. A.).

Craib refers *E. cerasiflorus* to the Campanulatus Series on account of its glabrous style, but in *E. chinensis* the style may vary from more or less pilose to glabrous; I find the style glabrous in Bock & Rosthorn no. 2080, Wilson nos. 3547 and 3549 and nearly glabrous in Wilson no. 1002; in the type of *Bodinierella Cavaleriei* the style is very sparingly pilose. I therefore do not believe that the glabrousness of the style can

be relied upon to distinguish *E. campanulatus* (Miq.) Nichols. *Bodinierella Cavaleriei* does not seem to be specifically distinct from *E. chinensis*, though the leaves and flowers are generally smaller. Craib in transferring it to *Enkianthus* under a new specific epithet does not discuss its relationship.

Cassiope selaginoides Hooker f. & Thompson in Hooker's Kew Jour. Bot. VII. 126, t. 4 (1885). — Léveillé, Cat. Pl. Yun-Nan, 86 (1915).

Cassiope Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 342 (1914); Cat. Pl. Yun-Nan, 86 (1915). — **Synon. nov.**

CHINA. Yunnan: sur rochers du Io-chan, 3200 m., *E. E. Maire*, June 1913 (holotype of *C. Mairei;* photo. and merotype in A. A.).

Leucothoë spec.

Pieris Cavaleriei Léveillé & Vaniot in Bull. Soc. Bot. France, LI. 292 (1904); LIII. 205 (1906); Fl. Kouy-Tchéou, 149 (1914).

CHINA. Kweichou: Pin-fa, chutes d'eau, précipes, *J. Cavalerie*, no. 780, Oct. 15, 1902 (holotype of *Pieris Cavaleriei;* photo. in A. A.).

This is apparently closely related to *L. Griffithiana* (Hook. f.) Clarke which differs according to the description in the subobtuse calyx-teeth, ovate and abruptly short-acuminate or acute in Cavalerie's specimen which is in young fruit. I have seen no material of *L. Griffithiana;* the difference in the shape of the calyx-teeth may not be as great as it seems and Cavalerie's specimen may be referable to *L. Griffithiana*.

Pieris formosa (Wall.) D. Don in Edinb. N. Philos. Jour. XVII. 159 (1834). — Léveillé, Cat. Pl. Yun-Nan, 87 (1916).

Pieris Bodinieri Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 253 (1903); Bull. Soc. Bot. France, LIII. 205 (1906); Fl. Kouy-Tchéou, 149 (1914); Cat. Pl. Yun-Nan, 87 (1916); Cat. Ill. Pl. Seu-Tchouen, pl. 24 (1918), MS. — **Synon. nov.**

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 9, April 2, 1902 (cited under *P. Bodinieri* in Fl. Kouy-Tchéou, l. c., together with no. 64; photo. in A. A.). Yunnan: environs de Yunnan-sen, c. dans la montagne, *E. Bodinier*, no. 60, Jan. 29, 1897 "arbuste, fl. blanches" (syntype of *P. Bodinieri;* ex Léveillé); *Fr. Ducloux*, March 9, 1893 (syntype of *P. Bodinieri;* ex Léveillé).

Pieris Bodinieri is at present represented in the Herbarium only by Cavalerie no. 9, while the two syntypes from Yunnan cannot be located. The species seems common in Yunnan and from Kweichou I have seen specimens collected by Y. Tsiang (no. 9369) and by Steward, Chiao and Cheo (no. 759).

Xolisma ovalifolia (Wall.) Rehder in Jour. Arnold Arb. v. 52 (1924).

Pieris ovalifolia (Wall.) D. Don in Edinb. Phil. Jour. XVII. 159 (1834). — Léveillé, Fl. Kouy-Tchéou, 150 (1914); Cat. Pl. Yun-Nan, 87 (1916).

Pieris Ulbrichii Léveillé in Bull. Soc. Bot. France, LIII. 205 (1906); Fl. Kouy-Tchéou, 150 (1914) "*Ulbrichiana.*" — **Synon. nov.**

Pieris Mairei Léveillé in Bull. Géog. Bot. XXV. 21 (1915); Cat. Pl. Yun-Nan, 87 (1916). — **Synon. nov.**

Vaccinium Mairei Léveillé, l. c. (1915); l. c. (1916).

CHINA. K w e i c h o u : without precise locality, *J. Esquirol,* no. 42, May 15, 1904 "arbrisseau, fleurs blanches" (holotype of *P. Ulbrichii;* photo. in A. A.). Y u n n a n : collines calcaires de Tcha-ho, 2600 m., *E. E. Maire,* July 1912 "arbuste peu rameux, haut 1.30 m., fleurs blanches" (holotype of *Pieris Mairei;* photo. in A. A.); brousse des montagnes à Kiao-me-ti, *E. E. Maire,* May 1912 (holotype of *Vaccinium Mairei;* merotype in A. A.).

Pieris Ulbrichii and *P. Mairei* had been referred already by J. Hutchinson to *P. ovalifolia* according to notes on the type sheets.

Xolisma ovalifolia var. **lanceolata** (Wall.) Rehder in Jour. Arnold Arb. v. 52 (1924).

Pieris ovalifolia var. *lanceolata* (Wall.) Clarke in Hook. f., Fl. Brit. Ind. III. 461 (1882). — Léveillé, Cat. Pl. Yun-Nan, 87 (1916).

Pieris kouyangensis Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 253 (1903); in Bull. Soc. Bot. France, LIII. 204 (1906); Fl. Kouy-Tchéou, 149 (1914); Cat. Pl. Yun-Nan, 87 (1916). — **Synon. nov.**

Pieris Mairei var. *parvifolia* Léveillé in Bull. Géog. Bot. XXV. 21 (1915); Cat. Pl. Yun-Nan, 87 (1916).

CHINA. K w e i c h o u : environs de Kouy-yang, c. sur les montagnes du Collège, *E. Bodinier,* no. 2264, May 18, 1898 "petit arbuste, 0.50 m., fleurs blanches" (holotype of *P. kouyangensis;* photo. in A. A.); collines arides de Tché-hai, 2500 m., *E. E. Maire,* June 1912 (holotype of *P. Mairei* var. *parvifolia;* photo. in A. A.).

Pieris kouyangensis and *P. Mairei* var. *parvifolia* have been referred to *P. ovalifolia* D. Don by J. Hutchinson. *Pieris Mairei* var. *parvifolia* represents a small-leaved form of var. *lanceolata.*

Xolisma villosa (Wall.) Rehd. var. **pubescens** (Franch.) Rehder in Jour. Arnold Arb. v. 53 (1924).

Pieris Henryi Léveillé in Bull. Soc. Bot. France, LIII. 204 (1906); Cat. Pl. Yun-Nan, 87 (1916). — Rehder, l. c. 54 (1924). — **Synon. nov.**

CHINA. Y u n n a n : Mengtze, mountains 6500 ft., *A. Henry,* no.

9681 "low shrub, 1 ft. high, flowers white" (holotype of *P. Henryi;* photo. in A. A.).

Pieris Henryi was referred by J. Hutchinson to *P. ovalifolia* according to a note on the type sheet. Judging only from Léveillé's description it was placed by me (l. c. 53, 54) tentatively under *X. villosa,* but the pubescent ovary shows that it belongs to var. *pubescens.*

Gaultheria yunnanensis (Franch.), comb. nov.

Vaccinium yunnanense Franchet in Jour. de Bot. IX. 368 (1895).

Gaultheria laxiflora Diels in Bot. Jahrb. XXIX. 515 (1900). — **Synon. nov.**

Pieris Fortunati Léveillé in Bull. Soc. Bot. France, LIV. 369 (1907); Fl. Kouy-Tchéou, 149 (1914); Cat. Pl. Yun-Nan, 87 (1916). — **Synon. nov.**

Pieris vaccinium Léveillé in Fedde, Rep. Spec. Nov. IX. 448 (1911). — **Synon. nov.**

Vaccinium yunnanense Franch. var. *Franchetiana* Léveillé, Fl. Kouy-Tchéou, 155 (1914). — **Synon. nov.**

Embelia Vanioti Léveillé, Fl. Kouy-Tchéou, 285 (1915).— **Synon. nov.**

CHINA. Kweichou: without precise locality, no. 666 (holotype of *Pieris Fortunati;* photo. in A. A.); montagnes de Lou-tsong-koan, c. dans les pentes boisées, *E. Bodinier,* no. 1659, June 12, 1897 "petit arbuste ou sous-arbrisseau, fl. blanches" (syntype of *Pieris vaccinium* and *Vaccinium yunnanense* var. *Franchetiana;* photo. in A. A.); environs de Gan-pin dans la montagne, *L. Martin,* July 28, 1898 (syntype of *Pieris vaccinium* and *V. yunnanense* var. *Franchetiana;* photo. in A. A.); moulins de Tong-tchéou, *J. Esquirol,* no. 3251, June 22, 1902 (holotype of *Embelia Vanioti;* photo. in A. A.). Yunnan: dans les bois à Tchen-fong-chan, *J. M. Delavay,* no. 3069, July 1894 "arbrisseau, fleurs blanches" (holotype of *V. yunnanense* in hb. Paris; photo. in A. A.).

It is evident from Franchet's description of his *Vaccinium yunnanense* that the plant can not belong to *Vaccinium,* for he describes the fruit (immature) as "capsula semi-inclusa globoso-depressa, tomentella."

Pieris Vaccinium was not mentioned as a synonym when Léveillé enumerated the two specimens on which this species was based under the new name *Vaccinium yunnanense* var. *Franchetiana* without description.

Vaccinium bracteatum Thunberg, Fl. Jap. 156 (1784). — Rehder & Wilson in Sargent, Pl. Wilson. I. 558 (1913). — Léveillé, Fl. Kouy-Tchéou, 154 (1914). — Nakai, Fl. Sylv. Kor. VIII. 58 (1919).

Pieris divaricata in Bull. Acad. Intern. Géog. Bot. XII. 252 (1903); in Bull. Soc. Bot. France, LIII. 206 (1906). — **Synon. nov.**

Pieris coreana Léveillé in Fedde, Rep. Spec. Nov. v. 281 (1908). — **Synon. nov.**

Pieris Fauriei Léveillé, l. c. (1908). — **Synon. nov.**

Vaccinium Taquetii Léveillé in Fedde, Rep. Spec. Nov. XII. 182 (1913).

KOREA. Quelpaert: secus torrentes, *U. Faurie*, no. 1866, July 1907 (holotype of *Pieris coreana;* photo. and isotype in A. A.); in petrosis silvarum, *U. Faurie*, no. 1865, June 1907 (holotype of *P. Fauriei;* photo. and isotype in A. A.); in silvis Hioton, *E. Taquet*, no. 1084, Oct. 1908 (holotype of *V. Taquetii;* photo. and isotype in A. A.).

CHINA. Kweichou: environs de Kouy-yang, bois de Kien-lin-chan, *E. Bodinier*, no. 2399, July 7, 1898, "grand arbuste, quelquefois petit arbre, branches très cassantes, fl. blanches, parfois legèrement rosées" (holotype of *Pieris divaricata;* photo. in A. A.).

Pieris divaricata, P. coreana and *P. Fauriei* have been already referred to *V. bracteatum* by W. E. Evans according to notes on the type sheets. *Vaccinium Taquetii* is enumerated as a synonym of *V. bracteatum* by Nakai (l. c.).

Vaccinium repens (Lévl.), comb. nov.

Pieris repens Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 252 (1903); in Bull. Soc. Bot. France, LIII. 205 (1906); Fl. Kouy-Tchéou, 150 (1914); Cat. Pl. Yun-Nan, 87 (1916).

Vaccinium mekongense W. W. Smith in Notes Bot. Gard. Edinb. IX. 133 (1916). — **Synon. nov.**

CHINA. Kweichou: montagnes entre Hin-y-fou et le fleuve Hoa-kiang, partie haute de la montagne, *E. Bodinier*, no. 1560, Apr. 20, 1897 "très petit arbuste, fleurs d'un blanc pourpré" (holotype of *P. repens;* photo. in A. A.). Yunnan: open situations on the Yung-chang—Mekong divide, Lat. 25° 15′ n., alt. 7-8000 ft., *G. Forrest*, no. 9887, May 1913, shrub of 2-5 ft., flowers creamy white, striped rose (holotype of *V. mekongense;* isotype in A. A.).

I am unable to find any characters to separate the two specimens cited above, even in the habit there is not much difference. The term "repens" applied by Léveillé to his species is misleading; the specimen clearly represents an upright shrub, about 20 cm. tall, without any sign of being creeping except the curved root-stock.

Vaccinium albidens Léveillé & Vaniot in Fedde, Rep. Spec. Nov. IX. 447 (1911); Fl. Kouy-Tchéou, 154 (1914).

CHINA. Kweichou: without precise locality, *J. Esquirol*, no. 379, June 1902 (holotype; photo. in A. A.).

The specimen is too incomplete to allow exact identification; the

small apparently immature fruits are short-stalked and borne in short rather dense racemes. Judging from the foliage it seems related to *V. Griffithianum* Wight, though the leaves are smaller than usually in that species.

Vaccinium mandarinorum Diels in Bot. Jahrb. XXIX. 516 (1901).—Metcalf in Jour. Arnold Arb. XII. 272 (1931).

Vaccinium Donianum Maximowicz in Mél. Biol. I. 608 (1872); in Bull. Acad. Sci. St. Pétersb. XVIII. 43 (1873), pro parte.

Pieris longicornu Léveillé & Vaniot in Bull. Soc. Bot. France, LI. 291 (1904); LIII. 206 (1906). — Léveillé, Fl. Kouy-Tchéou, 149 (1914).

Pieris Esquirolii Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 206 (1906). — Léveillé, Fl. Kouy-Tchéou, 149 (1914). — **Synon. nov.**

Pieris Esquirolii var. *discolor* Léveillé & Vaniot, l. c. (1906).

CHINA. Kweichou: Pin-fa, montagnes, *J. Cavalerie*, no. 1009, May 14, 1903, "1 à 2 m., fleurs blanches, étamines jaunes" (holotype of *Pieris longicornu;* photo. in A. A.); route de So-jao, face à Pa-pen, *J. Esquirol*, no. 12, April 3, 1904 (holotype of *P. Esquirolii;* photo. in A. A.); same locality, coteaux schisteux, *J. Esquirol*, nos. 10 and 13, April 3 and 4, 1904, "arbrisseau de 2 à 3 m., fl. blanc-rouge, sépales rougeâtres" (syntypes of *Pieris Esquirolii* var. *discolor;* photo. in A. A.).

Vaccinium mandarinorum is here accepted as a distinct species following Metcalf (l. c.), and this is now also the opinion of Dr. Handel-Mazzetti (in litt.) who referred, in Akad. Anzeig. Wiss. Wien. 1925, p. 146 (Pl. Nov. Sin. Forts. 35, p. 43), *Pieris longicornu* to *Vaccinium Donnianum*, while Anthony (Not. Bot. Gard. Edinb. XVIII. 16. 1933) is inclined to consider it specifically distinct. *Pieris Esquirolii* var. *discolor* represents a form with the leaves pubescent beneath; in one of the specimens, no. 13, the whole under-side is sparingly villous, more densely so in the veins, while in no. 10 only the midrib below the middle and the petiole is villous, a character also occasionally observed in otherwise typical *V. mandarinorum*.

Vaccinium Duclouxii (Lévl.) Handel-Mazzetti in Akad. Anz. Wiss. Wien, 1925, p. 146 (Pl. Nov. Sin. Forts. 35, p. 4) (1925).

Pieris Duclouxii Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 253 (1903); in Bull. Soc. Bot. France, LIII. 206 (1906); Cat. Pl. Yun-Nan, 87 (1916).

Vaccinium Forrestii Diels in Not. Bot. Gard. Edinb. v. 294 (1912).

CHINA. Yunnan: environs de Yun-nan-sen, bois de la pagode de Kiong-chou-se, *E. Bodinier*, no. 104, March 2, 1897, "grand arbuste de 2-3 m." (holotype of *Pieris Duclouxii;* photo. in A. A.); on the

same label the following additional localities are cited: "item à My-tsao, 6 mars 97, *Fr. Ducloux;* item mont Ma-kay, 4 April 97," but there is only one specimen on the sheet.

Anthony (Notes Bot. Gard. Edinb. XVIII. 16. 1933) refers *V. Duclouxii* as a synonym to *V. Donnianum* Wight, but it is easily distinguished from typical *V. Donnianum* by its rather short racemes and very short pedicels and the non-ciliate calyx, or ciliate only at the apex.

Vaccinium pubicalyx Franchet in Jour. de Bot. IX. 369 (1895). — Léveillé, Cat. Pl. Yun-Nan, 94 (1916).

Myrica Mairei Léveillé in Bull. Géog. Bot. XXV. 40 (1915); Cat. Pl. Yun-Nan, 177 (1915). — **Synon. nov.**

CHINA. Yunnan: brousse des montagnes à Kiao-me-ti, 3100 m., *E. E. Maire,* July 1912 "petit arbre peu rameux, fleurs jaunes" (holotype of *Myrica Mairei;* merotype in A. A.).

Maire gives the color of the flowers as yellow; in his specimen the flowers are still in bud and may be yellowish in that state, but the open flowers are white or pinkish white according to Handel-Mazzetti (no. 10129) and Rock (no. 5075).

Vaccinium pubicalyx var. **leucocalyx** (Lévl.) comb. nov.

Pieris Esquirolii Lévl. var. *leucocalyx* Léveillé in Bull. Soc. Bot. France, LIII. 206 (1906).

CHINA. Kweichou: route de So-Jao, face à Pa-pen, *J. Esquirol,* no. 11, 1904 "presque entièrement rouge, calice coloré" (holotype of *Pieris Esquirolii* var. *leucocalyx;* photo. in A. A.).

Pieris Esquirolii var. *leucocalyx* is perhaps best referred to *Vaccinium pubicalyx* Franch., with which it agrees in the pubescent calyx and the dense rather short racemes, but it differs in the leaves being only short-acuminate or acute and loosely villous on the under surface, more densely so on the midrib, and in the longer 2-4 cm. long racemes. In Flore du Kouy-Tchéou, Léveillé cites Esquirol no. 11 under *Pieris Esquirolii* without mentioning the varietal name.

Vaccinium malaccense Wight in Calcutta Jour. Nat. Hist. VIII. 172 (1847).

Pieris ovalifolia var. *denticulata* Léveillé in Bull. Soc. Bot. France, LI. 291 (1904).

Pieris lucida Léveillé, op. cit. LIII. 207 (1906); Fl. Kouy-Tchéou, 150 (1914). — **Synon. nov.**

CHINA. Kweichou: Tsin-gai (Kai-po), *J. Cavalerie* no. 1235, Aug. 5, 1903, "h. 3 à 4 m." (holotype of *Pieris ovalifolia* var. *denticulata* and *P. lucida;* photo. in A. A.).

Pieris lucida has been identified by Hutchinson as *Vaccinium malaccense.*

Vaccinium Dunalianum Wight var. **urophyllum** Rehder & Wilson in Sargent, Pl. Wilson. I. 560 (1913). — Léveillé, Cat. Pl. Yun-Nan, 94 (1916).

Pieris Martini Léveillé in Bull. Acad. Intern. Bot. Géog. XII. 252 (1903); in Bull. Soc. Bot. France, LIII. 204 (1906); Fl. Kouy-Tchéou, 150 (1914). — **Synon. nov.**

CHINA. Kweichou: environs de Gan-pin, mont de la ville, *L. Martin* in hb. *Bodinier*, no. 2308, June 5, 1898 "arbuste à fleurs blanches teintées de rose" (holotype of *Pieris Martini;* photo. in A. A.).

On account of the short-villous branchlets and petioles *Pieris Martini* is referable to var. *urophyllum* of *V. Dunalianum*, but the midrib and veins of the under side of the leaves are glabrous and thus the specimen represents a transition to the typical form. According to a note on the type sheet it was referred to *V. urceolatum* Hemsl., but that species is easily distinguished even without flowers by its short-petioled almost subsessile leaves rounded at the base.

Vaccinium foetidissimum Léveillé & Vaniot in Fedde, Rep. Spec. Nov. IX. 447 (1911); Fl. Kouy-Tchéou, 154 (1914).

Anisophyllea Cavalerici Léveillé, Fl. Kouy-Tchéou, 344 (1915). — **Synon. nov.**

CHINA. Kweichou: Niang-ouang, rocailles près ruisseau du Chang, rare, *J. Cavalerie*, no. 343, Oct. 15, 1907 "fruit violet-cendré, très puant" (holotype of *V. foetidissimum;* merotype in A. A.); Pin-fa, *J. Cavalerie*, no. 343, Aug. 31, 1902 (holotype of *Anisophyllea Cavaleriei;* photo. in A. A.).

This species is apparently closely related to *V. Dunalianum* Wight, but readily distinguished by narrow oblong-lanceolate or oblanceolate leaves 5-7 cm. long and 10-17 mm. wide, gradually narrowed into a very short petiole and acute, not acuminate, at the apex. The leaves strikingly resemble in shape and arrangement those of *V. angustilimbum* Merr. from the Philippine Islands, particularly those of Manila Bureau of Science no. 26603, except that the veins are more prominent beneath in the latter.

Vaccinium fragile Franchet in Jour. de Bot. IX. 366 (1895). — Léveillé, Cat. Pl. Yun-Nan, 94 (1916).

Pieris Gagnepainiana Léveillé in Bull. Acad. Intern. Bot. Géog. XII. 251 (1903); in Bull. Soc. Bot. France, LIII. 205 (1906); Cat. Pl. Yun-Nan, 87 (1916). — **Synon. nov.**

CHINA. Yunnan: environs de Yun-nan-sen, c. au pied des rochers, bord des sentiers de la montagnes, *E. Bodinier*, Dec. 3, 1896 "fleurs blanches à nervures pourpres" (holotype of *Pieris Gagnepainiana;* photo. in A. A.).

Pieris Gagnepainiana has been already identified with *V. fragile* by W. E. Evans according to a note on the type sheet. The specimen cited above represents the typical form named α. *crinita* by Franchet (l. c. 367).

Vaccinium triflorum, nom. nov.

Pieris buxifolia Léveillé & Vaniot in Bull. Soc. Bot. France, LIII. 203 (1906).

Vaccinium buxifolium Léveillé in Fedde, Rep. Spec. Nov. XII. 101 (1913); Fl. Kouy-Tchéou, 154 (1914). — Non Hooker f.

Frutex humilis, prostratus, ad 20 cm. longus, ramosus; ramuli hornotini villoso-pilosi, tarde glabrescentes, vetustiores pallide brunneo-cinerei. Folia congesta, coriacea, per plures annos persistentia, ovalia vel elliptica, rarius elliptico-obovata vel elliptico-oblonga, 1.4-2 cm. longa et 7-10 mm. lata, obtusa et leviter emarginata, basi late vel interdum angustius cuneata vel rotundata, margine integro cartilagineo recurva, supra convexa, bullato-rugosa, costa media impressa, initio sparsissime densius ad costam et basin versus pilosa, subtus costa media elevata, venis obsoletis, fuscescentia, initio ad costam sparse pilosa, demum glabra; petioli 1-2 mm. longi, initio villoso-pilosi, demum fere glabri vel glabri. Inflorescentiae axillares in ramis biennibus racemos pedunculatos abbreviatos 2-3-floros formantes; axis pedunculo incluso 2-5 mm. longa, breviter pilosula; pedicelli 3-6 mm. longi, graciles, pilosi, bracteis ovatis obtusiusculis circiter 1 mm. longis ciliatis suffulti; sepala ovata, acuminata, 1.5 mm. longa ut ovarium satis dense pilosa; corolla campanulata, 7-8 mm. longa, extus intusque glabra, alba vel flavo-alba, roseo-striata, ore vix vel non constricta, lobis late triangulari-ovatis, 2 mm. longis apice recurvis et dorso sparse pilosulis; staminą corollam subaequantia, filamentis villosis curvatis, antheris glabris tubulis apice alte fissis anthera longioribus inclusis 6 mm. longis, dorso appendiculis sursum curvatis circiter 1.5 mm. longis praeditis; stylus glaber, stamina paullo superans. Fructus non visus, ex collectore roseus, edulis.

CHINA. Kweichou: Mo-chie, Tchang-t'sai, *J. Esquirol,* no. 33, May 1904, "très pauciflore; feuilles de buis ridées en dessus, rougeâtres dessous, entières au bords, rameaux et petioles velues, corolla rouge" (holotype of *Pieris buxifolia;* photo. in A. A.); Tiey-sey-kiao, 900 m., *J. Esquirol,* no. 2095, May 1910, "fl. blanche panachée de rose" (syntype of *V. buxifolium;* photo. in A. A.); Gan-chouen, rochers, AR., *J. Cavalerie,* no. 3799, May-Sept. 1910, "fl. blanc-jaune, fruit rose mangeable" (syntype of *V. buxifolium;* photo. in A. A.).

This species is similar in general appearance to *V. Delavayi* Franch., *V. dendrocharis* Hand.-Mazz., *V. conchophyllum* Rehd. and *V. moupi-*

nense Franch., but differs from all of them in the axillary 2-3-flowered inflorescence, the pubescent calyx and the open-campanulate corolla. Since Léveillé's description is very brief and insufficient, I have given above a full description based on the three specimens cited which are remarkably uniform, except that the leaves of no. 2075 are more cuneate at the base resembling those of *V. Delavayi* Franch., while the leaves of no. 3799 resemble those of *V. conchophyllum* Rehd. which may be after all only a form of *V. Delavayi*.

Vaccinium japonicum Miquel in Ann. Mus. Bot. Lugd.-Bat. I. 28 (1863); Prol. Fl. Jap. 92 (1866).

Vaccinium Faurici Léveillé in Fedde, Rep. Spec. Nov. XII. 182 (1913). — **Synon. nov.**

KOREA. K o g e n P r o v.: in monte des diamantes, *U. Faurie,* no. 663, June 22, 1906 (holotype of *V. Fauriei;* photo. in A. A.).

Vaccinium japonicum var. **sinicum** (Nakai) Rehder in Jour. Arnold Arb. v. 56 (1924).

Agapetes vaccinioidea Léveillé in Bull. Acad. Intern. Géog. Bot. XII. 251 (1903); Fl. Kouy-Tchéou, 147 (1914). — **Synon. nov.**

Vaccinium siccum Léveillé & Vaniot in Fedde, Rep. Spec. Nov. IX. 447 (1911); Fl. Kouy-Tchéou, 154 (1914). — **Synon. nov.**

CHINA. K w e i c h o u: environs de Kouy-yang, mont du Collège çà et là, *E. Bodinier,* no. 1716bis, May 26, 1898, "petit sous-arbrisseau, fl. rosées-pourprées"; mont de Lou-tsong-koan, çà et là dans la montagne, *E. Bodinier,* no. 1716, July 21, 1897, "petit arbrisseau, très cassant" (syntypes of *Agapetes vaccinioidea;* merotype in A. A.); Ma-jo, *J. Cavalerie,* no. 3010, Nov. 1907 "fruits rouges" (holotype of *V. siccum;* photo. and merotype in A. A.).

MYRSINACEAE

Determined by E. H. WALKER

Maesa tenera Mez in Engler, Pflanzenr. IV.-236, p. 28 (1902).

Maesa Martini Léveillé, in Fedde, Rep. Spec. Nov. IX. 462 (1911); Fl. Kouy-Tchéou, 286 (1914). — **Synon. nov.**

CHINA. K w e i c h o u: bords du Hoa-kiang, *L. Martin* in hb. *Bodinier,* no. 2564, Feb. 18, 1899 (holotype of *Maesa Martini;* photo. in A. A.).

In his Flore du Kouy-Tchéou Léveillé enumerates *M. Martini* as a distinct species and on the same page as a synonym of *M. sinensis* A. DC. citing under it no. 2564 together with other numbers.

Maesa japonica (Thbg.) Moritzi apud Zollinger, Syst. Verz. Ind. Archip. III. 61 (1855). — Mez in Engler, Pflanzenr. IV.-236, p. 50, fig. 6 (1902).

Picris oligodonta Léveillé in Bull. Soc. Bot. France, LIV. 369 (1907); Fl. Kouy-Tchéou, 150 (1914). — **Synon. nov.**

Maesa Labordei Léveillé in Fedde, Rep. Spec. Nov. IX. 462 (1911).

Maesa Esquirolii Léveillé, l. c. (1911); Fl. Kouy-Tchéou, 150 (1914). — **Synon. nov.**

Maesa Cavaleriei Léveillé, l. c. (1911); l. c. (1919). — **Synon. nov.**

Maesa Dunniana Léveillé, l. c. 463 (1911); l. c. (1914). — **Synon. nov.**

Myrsine Esquirolii Léveillé, in Fedde, Rep. Spec. Nov. XII. 186 (1913); Fl. Kouy-Tchéou, 288 (1914). — **Synon. nov.**

Vaccinium oligodontum Léveillé, Fl. Kouy-Tchéou, 150 (1914), pro synon. *Pieridis oligodontae.*

CHINA. K w e i c h o u : without precise locality, *J. Esquirol,* no. 895 (holotype of *Pieris oligodonta;* photo. in A. A.); environs de Tsin-gay dans la montagne à Lo-ten, *J. Laborde* in hb. *Bodinier,* no. 2513, Nov. 28, 1898 (holotype of *M. Labordei;* photo. in A. A.); Hoang-tsao-pa, *J. Esquirol,* no. 1572, June 1909 (holotype of *M. Esquirolii;* photo. in A. A.); Tou-yun, *J. Cavalerie,* Nov. 10, 1899 (holotype of *M. Cavaleriei;* merotype and photo. in A. A.); Pin-fa, bois, *J. Cavalerie,* no. 459, Apr., July, Oct. 1907 "fleurs blanches, fruit blanc et graines noires" (syntypes of *M. Dunniana;* merotype in A. A.); bois de Bangnin, *J. Esquirol,* no. 2625, March 29, 1911 (holotype of *Myrsine Esquirolii;* photo. in A. A.).

The type specimen of *Pieris oligodonta* bears on the label only the name *Vaccinium oligodontum* in Léveillé's handwriting; the species was referred to *Maesa* first by J. Hutchinson according to a label on the type sheet, but under a new unpublished combination. *Maesa Labordei* is cited in the Flore du Kouy-Tchéou as a synonym of *M. Cavaleriei.*

Ardisia tenera Mez in Engler, Pflanzenr. IV.-236, p. 104 (1902).

Ardisia Meziana Léveillé in Fedde, Rep. Spec. Nov. X. 374 (1912); Fl. Kouy-Tchéou, 283 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : Lo-fou, *J. Cavalerie,* no. 3550 (errore 3530), March 1909 (holotype of *A. Meziana;* photo. in A. A.).

Ardisia brevicaulis Diels in Bot. Jahrb. XXIX. 519 (1900). — Mez in Engler, Pflanzenr. IV.-236, p. 143 (1902).

Ardisia Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 461 (1911); Fl. Kouy-Tchéou, 282 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : district de Tsin-gay, vallée de Ly-mou-tchay, dans les rocailles boisées, au bord de la rivière, *E. Bodinier,* Jan. 14, 1898 (holotype of *A. Bodinieri;* merotype and photo. in A. A.).

Ardisia crispa (Thbg.) A. De Candolle in Trans. Linn. Soc. XVII. 124 (1834). — Mez in Engler, Pflanzenr. IV.-236, p. 144 (1902).

Ardisia Labordei Léveillé in Fedde, Rep. Spec. Nov. X. 373 (1912); Fl. Kouy-Tchéou (1914). — **Synon. nov.**

Ardisia crispa var. *Taquetii* Léveillé in Fedde, Rep. Spec. Nov. x. 374 (1912). — **Synon. nov.**

Bladhia crispa Thbg. var. *Taquetii* (Lévl.) Nakai, Trees Shrubs Jap. 1. 208 (1922); Fl. Sylv. Kor. XIII. 16, pl. 5 (1923).

Ardisia Taquetii Léveillé in litt. ex Nakai, l. c. (1923), pro synon. var. *Taquetii.*

Bladhia lentiginosa (Ker) Nakai var. *Taquetii* Nakai, Trees Shrubs Jap. ed. 2, 1. 284 (1927).

KOREA. Quelpaert: in sylvis secus torrentes, Hongno, *E. Taquet,* no. 2975, Oct. 1909 (holotype of *A. crispa* var. *Taquetii;* photo. and isotype in A. A.).

CHINA. Kweichou: district de Tsin-gay, dans les bois à Kao-tchay, *J. Laborde* in hb. *Bodinier,* no. 2512, March 8, 1898 (holotype of *A. Labordei;* photo. in A. A.).

Ardisia crispa var. *Taquetii* Lévl. can hardly be separated as a distinct variety; it is said to differ chiefly in its longer less branched stems and longer leaves.

Ardisia elegans Andrews, Bot. Rep. x. t. 623 (1811).

Ardisia elegantissima Léveillé in Fedde, Rep. Spec. Nov. x. 373 (1912). — **Synon. nov.**

CHINA. Hongkong: bois de Happy Valley, *E. Bodinier,* no. 665, June 20, 1894 "arbuste de 1-2 m., branchant seulement en haut, les branches (ci-jointes) sont alternes et se séparent de la tige principale à l'angle droit formant une tête très elegante; fleurs roses, très belles, toutes retombantes." (holotype of *A. elegantissima;* photo. in A. A.).

This species, considered by Mez as a synonym of *Ardisia crispa* may be distinguished from that species by its almost total want of punctations and by the compound and more corymbose inflorescence on longer special branches, these with scattered leaves almost throughout their length. Léveillé's *A. elegantissima* corresponds in all essentials with the typical scallop-leaved forms considered to represent Andrews' species.

Ardisia Henryi Hemsl. var. **Dielsii** (Lévl.) Walker, comb. nov.

Ardisia Dielsii Léveillé in Fedde, Rep. Spec. Nov. IX. 461 (1911); Fl. Kouy-Tchéou, 282 (1914); Cat. Pl. Yun-Nan, 177 (1916).

CHINA. Kweichou: environs de Gan-pin, grande rocaille, dans les interstices des rochers, rare, *L. Martin* in hb. *Bodinier,* no. 1636, June 10, 1897 (syntype; photo. and merotype in A. A.); environs de Kouy-yang, mont du Collège, bois rocailles, rare, *E. Bodinier,* June 1, 1898 (syntype; ex Léveillé); Pin-fa, Tou-chan, *J. Cavalerie,* June 7, 1899 (syntype; photo. in A. A.).

Ardisia Dielsii has been referred to *A. Henryi* by Handel-Mazzetti according to a note on the type sheet of no. 1636. On the label of that

specimen Martin's name does not appear, while in Léveillé's description Bodinier's name is omitted from the citation of no. 1636. On Cavalerie's specimen from Pin-fa, which undoubtedly belongs here, neither the locality Tou-chan nor the date given by Léveillé appear.

From *A. Henryi* this variety differs in the longer and more slender leaves which are narrowly long-lanceolate, 12-20 cm. long and 1-4 cm. wide, the lateral nerves very clearly curved-ascending.

Ardisia Faberi Hemsley in Jour. Linn. Soc. Bot. XXVI. 64 (1889). — Mez in Engler, Pflanzenr. IV.-236, p. 153 (1902).

Ardisia castaneifolia Léveillé in Fedde, Rep. Spec. Nov. IX. 461 (1911). — Non Mez.

Ardisia Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. X. 374 (1912); Fl. Kouy-Tchéou, 282 (1914); Cat. Pl. Yun-Nan, 177 (1916). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Tou-chan, *J. Cavalerie* in hb. *Bodinier*, June 1899 (syntype of *A. castaneifolia;* photo. in A. A.); Pin-fa, chutes d'eau, *J. Cavalerie*, no. 751, Dec. 9, 1910 (syntype of *A. castaneifolia;* ex Léveillé); Pin-fa, *J. Esquirol*, June 15, 1905 "fleurs roses, fruits d'un rouge clair" (syntype of *A. Cavaleriei;* photo. in A. A.).

Since *Ardisia castaneifolia* Lévl. is invalidated by the earlier homonyms *A. castaneifolia* Mez, Léveillé changed the name to *A. Cavaleriei*, citing an additional specimen under that name.

Embelia oblongifolia Hemsley in Jour. Linn. Soc. XXVI. 62 (1889). — Mez in Engler, Pflanzenr. IV.-236, p. 316 (1902).

Embelia Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 327 (1911); Fl. Kouy-Tchéou, 284 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : without precise locality, *J. Esquirol*, no. 743 (holotype of *E. Bodinieri;* photo. in A. A.), no. 726 (cited in Fl. Kouy-Tchéou; duplicate in A. A.).

Embelia pauciflora Diels in Bot. Jahrb. XXIX. 517 (1900). — Mez in Engler, Pflanzenr. IV.-236, p. 325 (1902).

Embelia Schlechteri Léveillé in Fedde, Rep. Spec. Nov. X. 374 (1912); Fl. Kouy-Tchéou, 285 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège, à l'entrée d'une grotte, *E. Bodinier*, no. 2049, Feb. 1898 "petit arbuste" (holotype of *E. Schlechteri;* merotype in A. A.).

Of the type of *Embelia pauciflora* only a photograph has been seen which, however, so closely corresponds in all observable characters with the type of *E. Schlechteri*, that this reduction can safely be made. Also the proximity of the type localities lends support to their identity.

Embelia pauciflora var. **Blinii** (Lévl.) Walker, comb. nov.

Embelia Blinii Léveillé in Fedde, Rep. Spec. Nov. x. 375 (1912); Fl. Kouy-Tchéou, 284 (1914).

Embelia Dielsii Léveillé, l. c. 374 (1912); Fl. Kouy-Tchéou, 284 (1914). — **Synon. nov.**

Embelia Kaopoensis Léveillé in Fedde, Rep. Spec. Nov. XII. 186 (1913).

CHINA. Kweichou: Kouy-yang, mont du Collège, à Ke-ma-tong, *J. Chaffanjon* in hb. *Bodinier,* no. 2081, Feb. 1898 "liane de 2-3 m." (holotype of *E. Blinii;* merotype in A. A.); Pin-fa, bois, *J. Cavalerie,* no. 1327, Feb. 17, 1903 (holotype of *E. Dielsii;* photo. in A. A.); Kao-po, *E. Bodinier,* Dec. 15 (holotype of *E. Kaopoensis;* photo. in A. A.).

The variety corresponds, so far as available material reveals, in all respects with the species except in the leaf-shape which in the variety is narrowly oblong-lanceolate rather than ovate-lanceolate to ovate as in the species.

Embelia Kaopoensis was referred as a synonym to *E. Dielsii* by Léveillé in his Flore du Kouy-Tchéou.

Myrsine semiserrata Wallich in Roxburgh, Fl. Ind. II. 293 (1824); Mez in Engler, Pflanzenr. IV.-339 (1902). — Léveillé, Fl. Kouy-Tchéou, 288 (1914).

Celastrus Cavalerici Léveillé in Fedde, Rep. Spec. Nov. XIII. 262 (1914). — **Synon. nov.**

Celastrus Seguini Léveillé, l. c. (1914).

CHINA. Kweichou: Pin-fa, bois, rare, *J. Cavalerie,* no. 1744, Apr. 5, 1904 (holotype of *Celastrus Cavaleriei;* photo. in A. A.); environs de Hoang-ko-chou, rocailles de la cascade, *J. Seguin* in hb. *Bodinier,* no. 2609, March 15, 1899 "arbrisseau, plante femelle" (syntype of *Celastrus Seguini;* photo. in A. A.); environs de Kouy-yang, mont du Collège, sous les rochers de la cascade, *E. Bodinier,* no. 2180, March 30, 1898 "grand arbuste, plante femelle" (syntype of *C. Seguini;* photo. in A. A.).

Celastrus Seguini is cited by Léveillé in his Flore du Kouy-Tchéou (l. c.) as a synonym of *Myrsine semiserrata,* but Seguin, no. 2609, is not cited and Bodinier's no. 2180 is cited as no. 2181. *Celastrus Cavaleriei* is not cited as a synonym, but the type of this species, Cavalerie no. 1744, is enumerated under *Myrsine semiserrata* together with other Cavalerie numbers. *Celastrus Cavaleriei* Lévl. of 1914 cited above should not be confused with *C. Cavaleriei* Lévl. of 1916 (Monde des Pl. ser. 2, XVIII. 31) which is *C. stylosa* Wall. (Jour. Arnold Arb. XIV. 250).

Myrsine africana Linnaeus, Spec. Pl. 196 (1753). — Mez in Engler, Pflanzenr. IV.-236, p. 340, fig. 58 (1902).

Rhamnus myrtillus Léveillé in Fedde, Rep. Spec. Nov. XII. 535 (1913); Fl. Kouy-Tchéou, 343 (1915); Cat. Pl. Yun-Nan, 228 (1917). — **Synon. nov.**

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie*, no. 840, March 9, 1902 "fl. rouges" (cited in Fl. Kouy-Tchéou under *Rhamnus myrtillus;* duplicate in A. A.). Y u n n a n : collines de Tong-tchouan, sous bois, alt. 2550 m., *E. E. Maire*, in 1912 "arbrisseau buissonant toujours vert, haut 0.30 m., fl. vertes, fruit noir" (holotype of *Rhamnus myrtillus;* merotype in A. A.).

Rapanea neriifolia (S. & Z.) Mez in Engler, Pflanzenr. IV.-236, p. 361 (1902).

Myrsine Seguini Léveillé, Fl. Kouy-Tchéou, 228 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Ou-la-gay, pref. de Chen-lin, dans les rocailles, *J. Seguin* in hb. *Bodinier*, no. 2253, Apr. 10, 1898, "grand arbuste" (holotype of *Myrsine Seguini;* merotype in A. A.).

PRIMULACEAE

Determined by H. HANDEL-MAZZETTI[1]

Lysimachia Navillei (Lévl.) Handel-Mazzetti, comb. nov.

Diospyros Navillei Léveillé, Fl. Kouy-Tchéou, 145 (1914).

Lysimachia solanoides Handel-Mazzetti in Not. Bot. Gard. Edinb. XVI. 70 (1928).

CHINA. K w e i c h o u : Tchei-tchou, *J. Esquirol*, no. 749, Aug. 1905, "fl. blanche" (holotype of *Diospyros Navillei;* photo. in A. A.; a duplicate of this number is a syntype of *L. solanoides*).

There are apparently two specimens of Esquirol's no. 749 in the Herbarium Léveillé; one is cited under *Diospyros Navillei* with the locality given as "Tchei-tchou" and one under *Lysimachia foenum-graecum* (Fl. du Kouy-Tchéou, 324. 1915) with the locality "Tche-tchou." The latter is one of the two specimens on which Handel-Mazzetti based his *L. solanoides*. By Léveillé the specimen of *D. Navillei* is cited as no. 249, by Handel-Mazzetti as no. 749. The latter is correct; the first figure of the number on the label in the Herb. Léveillé is partly cut off, so that it looks like "2," but the correct number 749 in blue pencil is found on the same label.

[1]Only those species of *Lysimachia* are enumerated here which had been referred by Léveillé to ligneous genera.

Lysimachia lancifolia Craib in Kew Bull. Misc. Inform. 1918, p. 363. — Handel-Mazzetti in Not. Bot. Gard. Edinb. XVI. 72 (1928).

Ardisia Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XII. 186 (1913); Fl. Kouy-Tchéou, 283 (1914); non *Lysimachia Esquirolii* Bonati (1913). — **Synon. nov.**

CHINA. K w e i c h o u : chute d'eau de Hoang-tsao-pa, *J. Esquirol*, no. 1546, June 1909 "fleurs jaunes" (holotype of *Ardisia Esquirolii;* photo. and merotype in A. A.).

Lysimachia capillipes Hemsl. var. **Cavaleriei** (Lévl.) Handel-Mazzetti, comb. nov.

Andrachne Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. XII. 187 (1913); Fl. Kouy-Tchéou, 158 (1914).

CHINA. K w e i c h o u : Ta-ting, grotte no. 2, alt. 630 m., *J. Esquirol*, no. 2238, Sept. 1910 (holotype of *Andrachne Cavaleriei;* photo. in A. A.).

SAPOTACEAE

Sideroxylon Wightianum Hooker & Arnott, Bot. Beechey Voy. 196, t. 41 (1841).

Rhamnus coriaceifolius Léveillé in Fedde, Rep. Spec. Nov. XII. 535 (1913); Fl. Kouy-Tchéou, 342 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Chouang-chan-po, *J. Esquirol*, no. 3142, May 1911 (holotype of *Rhamnus coriaceifolius;* photo. and merotype in A. A.).

Sideroxylon Wightianum has apparently not been reported as yet from western and central China.

EBENACEAE

Diospyros mollifolia Rehder & Wilson in Sargent, Pl. Wilson. II. 591 (March 30, 1916). — Léveillé, Cat. Pl. Yun-Nan, 83 (1916).

Diospyros Mairei Léveillé, Cat. Pl. Yun-Nan, 83 (May 5, 1916). — **Synon. nov.**

CHINA. Y u n n a n : collines arides rocheuses derrière Lo-kou, 2450 m., *E. E. Maire*, May 1912 "grand arbuste, très rameux; fl. jaune-verdâtres" (holotype of *D. Mairei;* merotype in A. A.).

Diospyros Esquirolii Léveillé, Fl. Kouy-Tchéou, 145 (1914).

CHINA. K w e i c h o u : ramparts de Kouy-yang-fou, *J. Esquirol*, no. 449, May 1905 "arbre 12 à 14 m." (holotype; merotype and photo. in A. A.).

According to a note on the type sheet Handel-Mazzetti considers this a good species related to *D. dumetorum* W. W. Sm.

Diospyros kaki L. f. var. **silvestris** Makino in Tokyo Bot. Mag. XXII. 159 (1908).

Diospyros Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 550 (Cat. Pl. Kiang-Sou, 10) (1916). — **Synon. nov.**

CHINA. K i a n g s u : Sou-tchéou-fou; Ve-ven; Tchong-tchéou-fu, Ven-sie, iles du Se-men, Ta-hou, *Ch. d'Argy* [1861-74] (holotype of *D. Argyi;* photo. in A. A.).

Though six localities are numerated on the folder of the specimen and cited by Léveillé, there is only one specimen with fragments of ripe fruits in the Herbarium Léveillé. According to a note on the type sheet this specimen was identified by Handel-Mazzetti as *D. kaki* var. *silvestris*.

STYRACACEAE

Pterostyrax Leveillei (Fedde) Chun in Hooker's Icon. Pl. XXXII. t. 3161 (1932).

Styrax Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 447 (1911). — Non Léveillé (1907).

Styrax Leveillei Fedde apud Léveillé, Fl. Kouy-Tchéou, 407 (1915).

Pterostyrax Cavaleriei (Lévl.) Guillaumin in Bull. Soc. Bot. France, LXX. 886 (1924).

CHINA. K w e i c h o u : route de Pin-fa à Tou-yun, rare, *J. Cavalerie,* no. 2992, May 1905, "fleur blanc-cendre" (holotype of *Styrax Cavaleriei* of 1911 and of *S. Leveillei;* photo. in A. A.).

This species, easily distinguished from the other species of the genus by its tricuspidate leaves, has also been found in Kwangsi near the Kweichou border (R. C. Ching, no. 2962).

Styrax Argyi Léveillé in Fedde, Rep. Spec. Nov. XI. 64 (1912); Fl. Kouy-Tchéou, 407 (1915).

Styrax iopilina Diels in Notizbl. Bot. Gart. Mus. Berlin, IX. 1028 (1926). — **Synon. nov.**

CHINA. K i a n g s u : without precise locality, *Ch. d'Argy,* (1861-74) (holotype; merotype in A. A.).

I have little doubt that *S. iopilina* Diels which is represented in this herbarium by an isotype and photograph of the type, is referable as a synonym to *S. Argyi.* Since the latter is known only with flower buds and the former with fruits, the comparison has to depend on vegetative characters and the inflorescence, in which I can find no difference.

Styrax japonicus Siebold & Zuccarini, Fl. Jap. I. 53, t. 23 (1835). — Perkins in Engler, Pflanzenr. IV.-241 (Heft 30), 73 (1907).

Styrax Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IV. 332 (1907); Fl. Kouy-Tchéou, 407 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : environs de Kouy-yang, mont du Collège, *E. Bodinier*, no. 2221, Apr. 1898 "grand arbuste a fleurs blanches odorantes" (holotype of *S. Bodinieri;* photo. in A. A.).

Styrax Bodinieri was first identified with *S. japonicus* by W. W. Smith according to a note on the type sheet.

Styrax grandiflorus Griffith, Notul. Pl. As. IV. 287 (1854). — Perkins in Engler, Pflanzenr. IV.-241 (Heft 30), 75 (1907).

Styrax Cavalerici Léveillé in Fedde, Rep. Spec. Nov. IV. 331 (1907); Fl. Kouy-Tchéou, 407 (1915). — **Synon. nov.**

Styrax touchanensis Léveillé in Fedde, Rep. Spec. Nov. XI. 64 (1912); Fl. Kouy-Tchéou, 407 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Long-ly, *J. Cavalerie*, no. 997, May 7, 1903, "fleurs blanches" (holotype of *S. Cavaleriei;* merotype in A. A.); Tou-chan, *E. Bodinier*, April 1902 (holotype of *S. touchanensis;* merotype in A. A.).

Styrax touchanensis and *S. Cavaleriei* have been determined by W. W. Smith as *S. grandiflorus* according to notes on the type sheet; the second species as *S. grandiflorus* forma.

SYMPLOCACEAE

Symplocos setchuensis Brand in Bot. Jahrb. XXIX. 528 (1900); in Engler, Pflanzenr. IV.-242 (Heft 6), 31 (1901).

Symplocos Argyi Léveillé in Fedde, Rep. Spec. Nov. X. 431 (1912); in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 562 (Cat. Pl. Kiang-Sou, 22) (1916). — **Synon. nov.**

CHINA. K i a n g s u : Y-hien-hien, Long-ze près Tsang-fou, *Ch. d'Argy* (1861-74) (holotype of *S. Argyi;* merotype in A. A.).

Symplocos coronigera Léveillé in Fedde, Rep. Spec. Nov. X. 431 (1912); Fl. Kouy-Tchéou, 409 (1915).

Symplocos Wilsonii Brand in Fedde, Rep. Spec. Nov. III. 216 (Dec. 31, 1906); non Hemsley (July 1906). — **Synon. nov.**

Symplocos xanthoxantha in Bull. Géog. Bot. XXIV. 283 (1914); Cat. Pl. Yun-Nan, 268 (1917). — **Synon. nov.**

CHINA. W e s t e r n H u p e h : north and south of Ichang, *E. H. Wilson*, Veitch Exp. no. 58, April, Sept. 1900 (syntypes of *S. Wilsonii;* isotypes in A. A.). E a s t e r n S z e c h u a n : Tchen-kéou-tin, *P. Farges*, no. 796 (syntype of *S. Wilsonii;* isotype in A. A.). K w e i c h o u : Ma-jo, *J. Cavalerie*, no. 3106, July 24, 1897 (holotype of *S. coronigera;* merotype in A. A.). Y u n n a n : sous bois de montagnes de Mo-tsou, alt. 3000 m., *E. E. Maire*, April 1913 (holotype of *S. xanthoxantha;* photo. in A. A.).

Symplocos xanthoxantha was first identified with *S. Wilsonii* Brand

by A. Guillaumin according to a note on the type specimen dated 22, III. 1924, but *S. Wilsonii* Brand is invalidated by the earlier homonym *S. Wilsonii* Hemsl. which is identical with *S. stellaris* Brand. *Symplocos coronigera* is closely related to *S. setchuensis*, from which it chiefly differs in the bracts and sepals being glabrous on the back, also in the usually oblong fruit 8-12 mm. long (ovoid and about 6-7 mm. long in *S. setchuensis*), in the generally longer petioles and in the usually somewhat larger inflorescence often with a distinct axis which in fruit may be 5-10 mm. long. The species has been often confused with *S. setchuensis*, of which it may be only a variety; most western specimens usually referred to *S. setchuensis* belong to *S. coronigera*, as do all the specimens from Yunnan I have seen, additional specimens from Kweichou (W. Y. Chun, no. 7746, and A. N. Steward, Chias & Cheo, no. 486) and most of the specimens from Szechuan. In the eastern provinces *S. coronigera* does apparently not occur and all the material before me from Chekiang and Kiangsi is *S. setchuensis*.

Symplocos paniculata (Thbg.) Miquel in Ann. Mus. Bot. Lugd.-Bat. III. 102 (1867); Prol. Fl. Jap. 266 (1867).

Symplocos crataegoides Hamilton apud D. Don, Prodr. Fl. Nepal. 145 (1825). — Léveillé, Fl. Kouy-Tchéou, 409 (1914); Cat. Pl. Yun-Nan, 268 (1917). — Brand in Engler, Pflanzenr. IV.-242 (Heft 6), 33 (1901).

Symplocos paniculata Wallich ex Don, Fl. Nepal. 145 (1825), pro synon. *S. crataegoidis*. — Wallich, Num. List, no. 4429 (1832), nom. nud.

Cotoneaster coreanus Léveillé in Fedde, Rep. Spec. Nov. XI. 64 (1912). — **Synon. nov.**

Prunus Mairei Léveillé in Bull. Géog. Bot. XXV. 45 (1915); Cat. Pl. Yun-Nan, 233 (1917). — **Synon. nov.**

Crataegus Lyi Léveillé, Fl. Kouy-Tchéou, 346 (1915). — **Synon. nov.**

Prunus Lyi Blin ex Léveillé, l. c. (1915), pro synon. *Crataegi Lyi*.

KOREA. Quelpaert: in sylvis Hallaisan, 1400 m., *E. Taquet*, no. 1106, Sept. 7, 1908 (holotype of *Cotoneaster coreanus;* merotype and isotype in A. A.).

CHINA. Kweichou: route de Gan-pin à Kouy-yang, *J. Cavalerie*, no. 2098, pro parte (fr.) (holotype of *Crataegus Lyi;* photo. in A. A.). Yunnan: flanc de montagne à Pé-long-tsin, 3200 m., *E. E. Maire*, May (1912?), "arbre-moyen, fl. blanches" (syntype of *Prunus Mairei;* merotype in A. A.); rochers du plateau de Sin-tang, 2800 m. *E. E. Maire*, May 1912 (syntype of *P. Mairei*, ex Léveillé).

Symplocos paniculata biloba f. (Lévl.), stat. nov.

Crataegus biloba Léveillé, Fl. Kouy-Tchéou, 346 (1915).

CHINA. K w e i c h o u : route de Gan-pin à Kouy-yang, *J. Cavalerie*, no. 2098, pro parte (fl.) (holotype of *Crataegus biloba;* photo. in A. A.).

This is an interesting variation with all the leaves distinctly obcordate and deeply emarginate at the apex. The leaf of *S. paniculata* is normally elliptic or oval to oblong and acute or acuminate at the apex, but sometimes at least part of the leaves are rounded at the apex and occasionally slightly emarginate as in Henry no. 9948, Rock no. 3160, and Schoch no. 50 from Yunnan and H. H. Hu 1598 from Chekiang.

Symplocos fasciculata Zoll. var. **chinensis** Brand in Fedde, Rep. Spec. Nov. III. 217 (1906).

Symplocos Stapfiana Léveillé in Fedde, Rep. Spec. Nov. IX. 444 (1911); Fl. Kouy-Tchéou, 410 (1915). — **Synon. nov.**

CHINA. K w e i c h o u : Kai-tchéou, Ma-jo, *J. Cavalerie*, no. 3287, June-Aug. 1908, "arbre à fleurs blanches, fruits noirs" (holotype of *S. Stapfiana;* photo. in A. A.).

Symplocos Stapfiana has been identified by A. Guillaumin as *S. fasciculata* var. *chinensis* according to a note on the type sheet. I have not seen the type of Brand's variety which is described as having 30-40-flowered fascicles; Cavalerie's plant has the flowers in 5-7-flowered solitary racemes only occasionally with 1 to 2 branches at the base. Léveillé describes the fruit but I have seen only a flowering specimen.

Symplocos pinfaensis Léveillé in Fedde, Rep. Spec. Nov. IX. 77 (1910).

Symplocos spicata Léveillé, Fl. Kouy-Tchéou, 410 (1915), pro parte, quoad Cavalerie 838; vix Roxburgh.

CHINA. K w e i c h o u : Pin-fa, *J. Cavalerie*, no. 838, March 18, 1902, "fl. blanches odorantes" (holotype; photo. in A. A.).

This species resembles very much *S. terminalis* Brand, but the two inflorescences present are simple short racemes, the flowers have fewer stamens, about 20, and the leaves are chartaceous with the veins above slightly raised, not impressed as in *S. terminalis*. It also resembles the following species, but differs in the short racemes, fewer stamens and in the smaller and comparatively broader leaves. It may also be compared with *S. lancifolia* S. & Z. and *S. caudata* Wall. which both have simple racemes, but smaller flowers partly stalked in the latter.

Symplocos laurina (Retz.) Wallich, Num. List, no. 4416 (1832). — Rehder & Wilson in Sargent, Pl. Wilson. II. 594 (1916).

Symplocos spicata Roxburgh, Cat. Hort. Beng. 40 (1814), nom. nud.; Fl. Ind. ed. 2, II. 541 (1832). — Léveillé, Fl. Kouy-Tchéou, 410 (1915), excl. no. 838; Cat. Pl. Yun-Nan, 268 (1917).

Eurya Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 450 (1911).
Maesa Bodinieri Léveillé & Blin in Léveillé, Fl. Kouy-Tchéou, 286 (1914). — **Synon. nov.**
Symplocos vinoso-dentata Léveillé in Bull. Géog. Bot. XXIV. 283 (1914); Fl. Kouy-Tchéou, 410 (1915). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, Juin-ou-chan, *J. Cavalerie,* no. 406, Sept. 8, 1902 (holotype of *Eurya Cavaleriei* and *Maesa Bodinieri;* photo. in A. A.). Yunnan: colline de Long-ky, 500 m., *E. E. Maire,* June 1913, "gros arbre à feuilles persistantes, fl. jaunâtre" (holotype of *S. vinoso-dentata;* merotype in A. A.).

In his Flore du Kouy-Tchéou (l. c.) Léveillé transferred *Eurya Cavaleriei* to *Maesa* as *M. Bodinieri.* In Cavalerie no. 406 the leaves are only sparingly denticulate above the middle, while in Maire's specimen they are serrate except near the base; in both specimens they are oblong to oblong-lanceolate and about 15 cm. long. Both specimens are referable to var. *acuminata* (Bl.) Brand which, however, hardly differs enough to be maintained as a distinct variety.

Symplocos lancifolia Siebold & Zuccarini in Abh. Akad. Muench. IV. pt. 3, p. 133 (Fl. Jap. Fam. Nat. II. 9) (1846). — Brand in Engler, Pflanzenr. IV.-242, p. 41 (1901).

Symplocos aurea Léveillé in Fedde, Rep. Spec. Nov. IX. 445 (1911); Fl. Kouy-Tchéou, 409 (1915). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, hautes montagnes, *J. Cavalerie,* no. 2312, April 26, 1906 "arbre 2 m., fleurs blanches, legèrement odorantes" (holotype of *S. aurea;* merotype in A. A.).

Symplocos Bodinieri Brand in Fedde, Rep. Spec. Nov. III. 217 (1906).

Symplocos Balfourii Léveillé in Fedde, Rep. Spec. Nov. IX. 77 (1910); Fl. Kouy-Tchéou, 409 (1915). — **Synon. nov.**
Maesa aurea Léveillé in Fedde, Rep. Spec. Nov. X. 375 (1912); Fl. Kouy-Tchéou, 286 (1914). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, bois, *J. Cavalerie,* no. 2527, Oct. 11, 1905, "arbuste, fl. blanches" (holotype of *S. Balfourii;* photo. in A. A.); environs de Tou-chan, *J. Cavalerie,* no. 2719, Oct. 1, 1899 "arbuste" (holotype of *Maesa aurea;* photo. in A. A.; a duplicate in hb. Paris being the holotype of *S. Bodinieri* Brand).

Symplocos Balfourii has been identified in 1924 by Guillaumin as *S. Bodinieri* according to a note on the type sheet. Cavalerie 2719 in herb. Léveillé is the type of *Maesa aurea* and another specimen of Cavalerie 2719 in herb. Paris is the type of *S. Bodinieri* Brand, though by Brand the number is cited as 2179, which apparently is a misprint for 2719.

Symplocos botryantha Franchet in Nouv. Arch. Mus. Paris, sér. 2, x. 60 (Pl. David. II. 98) (1888). — Brand in Engler, Pflanzenr. IV.-242, p. 60 (1901).

Symplocos caerulea Léveillé in Fedde, Rep. Spec. Nov. IX. 77 (1910); Fl. Kouy-Tchéou, 409 (1915). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, *J. Cavalerie,* nos. 2293, 2403, April 13 and June 5, "petit arbre, fl. blanches et bleu d'azur" (syntypes of *S. caerulea;* merotype (June 5) and photo. (Apr. 13) in A. A.).

Symplocos Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. IX. 77 (1910); Fl. Kouy-Tchéou, 409 (1915).

CHINA. Kweichou: Pin-fa, Niang-ouang, *J. Cavalerie,* no. 1022, May 28, 1903, "arbrisseau" (holotype; photo. in A. A.).

This species seems to be related to *S. botryantha,* but is easily distinguished by the small obovate-oblong, closely crenate-serrulate leaves rather abruptly contracted into a short obtuse acumen, and by the small fruit in short racemes.

Symplocos Martini Léveillé in Fedde, Rep. Spec. Nov. IX. 77 (1910); Fl. Kouy-Tchéou, 410 (1915).

CHINA. Kweichou: Kouy-yang, mont du Collège, *E. Bodinier,* April 1898 (holotype; photo. in A. A.).

This is very similar to *S. botryantha* Franch., but the leaves are broader, generally elliptic and the calyx-tube is silky-strigose.

Symplocos punctata Brand in Fedde, Rep. Spec. Nov. III. 217 (1906).

Symplocos Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 76 (1910); non Brand.

Symplocos splendens Léveillé in Fedde, Rep. Spec. Nov. XII. 186 (1913); Fl. Kouy-Tchéou, 410 (1915); Cat. Ill. Pl. Seu-Tchouen. pl. 62 (1918) MS. — **Synon. nov.**

CHINA. Kweichou: environs de Kouy-yang, dans les bois de la pagode de Kien-lin-chan, rare, *E. Bodinier,* no. 2224, April 14, 1898, "arbre de moyenne hauteur à belles fleurs bleues d'une odeur delicieuse" (holotype of *S. Bodinieri* and *S. splendens;* photo. in A. A.; an isotype in herb. Paris being the holotype of *S. punctata* Brand).

Symplocos punctata Brand and *S. Bodinieri* Lévl. are both based on Bodinier's no. 2224, the former on a specimen in the Paris herbarium, the latter on one in the herbarium Léveillé. The name *S. Bodinieri* was changed later by Léveillé to *S. splendens* on account of the earlier *S. Bodinieri* Brand.

Symplocos anomala Brand in Bot. Jahrb. XXIX. 67 (1900); in Engler, Pflanzenr. IV.-242, p. 67 (1901).

Symplocos Dielsii Léveillé in Fedde, Rep. Spec. Nov. IX. 445 (1911); Fl. Kouy-Tchéou, 409 (1915). — **Synon. nov.**
Symplocos Esquirolii Léveillé, l. c. (1911); l. c. (1915). — **Synon. nov.**

CHINA. Kweichou: route Pin-fa à Long-ly, bois, *J. Cavalerie*, no. 3330, Aug. 10, 1908 (holotype of *S. Dielsii;* photo. in A. A.); Pin-fa, Ma-jo, *J. Cavalerie*, no. 2380, June 1908, "arbrisseau" (holotype of *S. Esquirolii;* merotype in A. A.).

Symplocos Dielsii has been identified by A. Guillaumin with *S. anomala* according to a note on the type sheet. *Symplocos Esquirolii* I refer to the same species, though the fruits are up to 1 cm. long, but the leaves agree exactly with those of *S. anomala*.

Symplocos adenopus Hance in Jour. Bot. XXI. 322 (1883). — Brand in Engler, Pflanzenr. IV.-242, p. 67 (1901).
Symplocos Prainii Léveillé in Fedde, Rep. Spec. Nov. IX. 445 (1911); Fl. Kouy-Tchéou, 410 (1915). — **Synon. nov.**

CHINA. Kweichou: route de Pin-fa à Tou-yun, bois, rare, *J. Cavalerie*, no. 2966, Aug. 2, 1908, "arbre, fl. blanc-rosée" (holotype of *S. Prainii;* photo. and merotype in A. A.).

Cavalerie no. 2966 differs slightly from the type of *S. adenopus* in its leaves having a tendency toward an oblong-ovate shape being mostly broadest below the middle, while in the type specimen the leaves are slightly broader above the middle.

Symplocos stellaris Brand in Bot. Jahrb. XXIX. 528 (1900); in Engler, Pflanzenr. IV.-242, p. 68 (1901).
Symplocos Dunniana Léveillé in Fedde, Rep. Spec. Nov. IX. 445 (1911); Fl. Kouy-Tchéou, 409 (1915). — **Synon. nov.**
Litsea Chaffanjonii Léveillé in Fedde, Rep. Spec. Nov. XII. 182 (1913); Fl. Kouy-Tchéou 220 (1914). — **Synon. nov.**
Symplocos neriifolia Guillaumin in Lecomte, Fl. Gén. Indochine, III. 1011 (1933), quoad syn. *S. Dunnianus*. — Non Sieb. & Zucc.

CHINA. Kweichou: route de Pin-fa à Tou-yun, bois, *J. Cavalerie*, no. 3016, May 10, 1908, "arbre, fl. blanc-rose, odor." (holotype of *S. Dunniana;* photo. in A. A.); environs de Kouy-yang, mont du Collège, *J. Chaffanjon*, no. 2244, April 15, 1898, "arbre" (holotype of *Litsea Chaffanjonii;* photo. in A. A.).

Symplocos Mairei Léveillé in Monde Pl. ser. 2, XVIII. 28 (1916), Cat. Pl. Yun-Nan, 268 (1917).

CHINA. Yunnan: brousse des collines à Long-ky, 500 m., *E. E. Maire*, June 1912 "petit arbre à feuilles persistentes, fl. jaunes" (holotype; merotype in A. A.).

This species is very similar to the preceding species, but the margin of

the leaves is rather closely and finely denticulate nearly to the base with 3-4 teeth to 1 cm. almost reduced to a gland-like conical mucro, and the lateral veins and transverse veinlets are prominent beneath and impressed above; the not fully open closely fascicled flowers are smaller, with broader and shorter petals and quite glabrous, not ciliate, calyx-lobes. I have not been able to identify it with any described species.

In the Herb. Léveillé there is another specimen from the same locality named in Léveillé's handwriting "*Symplocos Mairei* Lévl." which represents an entirely different species. It is very similar and apparently referable to *S. myriantha* Rehd. from Szechuan, but the inflorescences are much less branched and in several instances consist of simple short racemes, but some have at the base small branches with a few crowded flowers. Shape and venation of the leaves are exactly the same and so is the pubescence of the inflorescence and the color of the branches. The flowers of Maire's specimen, however, seem to be somewhat larger, but they are almost all fully open, while those of the type of *S. myriantha* are still in bud.

OLEACEAE

Fontanesia Fortunei Carrière in Rev. Hort. 1859, p. 43. — Schneider, Ill. Handb. Laubholzk. II. 809, fig. 511a-d (1911).

Fontanesia Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 557 (Cat. Pl. Kiang-Sou, 17) (1916). — **Synon. nov.**

CHINA. Kiangsu: Siao-tse-jang, *Ch. d'Argy* [1861-74], "sepes vivas et densas constituit" (holotype of *F. Argyi;* merotype in A. A.).

Fraxinus Griffithii C. B. Clarke in Hooker f., Fl. Brit. Ind. III. 605 (1882). — Lingelsheim in Engler, Pflanzenr. IV.-243[I-II], p. 15 (1920).

Ligustrum Vanioti Léveillé, Cat. Pl. Yun-Nan, 181 (1916). — **Synon. nov.**

CHINA. Yunnan: rochers de Ma-hong, 3000 m., *E. E. Maire,* June 1912, "petit arbre, feuilles caduques, fl. blanches" (holotype of *Ligustrum Vanioti;* photo. in A. A.).

Léveillé apparently mistook the pinnate leaves for slender branchlets with simple leaves and did not examine the flowers closely.[1]

Syringa Mairei (Lévl.), comb. nov.

Ligustrum Mairei Léveillé, Cat. Yun-Nan, 181 (1916).

Syringa rugulosa McKelvey in Jour. Arnold Arb. VI. 153 (1925); Lilacs, 148 (1928). — **Synon. nov.**

[1]Under the genus *Fraxinus* Léveillé described only one new species, *Fraxinus Fauriei* (Fedde, Rep. Spec. Nov. VIII. 285, 1910) from Quelpaert, based on Faurie no. 1867; this turns out to be *Meliosma Oldhamii* Miq. and has been already referred to that species by Nakai in 1918 (Tokyo Bot. Mag. XXXII. 119. 1918).

China. Yunnan: brousse des montagnes à Tcha-ho, 2600 m., *E. E. Maire,* July (1910-13), "arbuste buissonant, haut 1.80 m.; fl. rose violacé" (holotype of *Ligustrum Mairei* in Herb. Léveillé and holotype of *Syringa rugulosa* in Herb. Edinb.; photos. of both in A. A.); brousse des montagnes a Pe-long-tsin, 3000 m., *E. E. Maire,* June [1910-13], "petit arbre buissonant, peu rameaux, fl. blanches, en grappes dressées" (paratype of *S. rugulosa;* in Herb. A. A.).

Ligustrum Mairei and *Syringa rugulosa* are based on two specimens of the same collection. The identity of both has been first established in the herbarium at Edinburgh according to a note on the cover of the specimen.

Syringa Fauriei Léveillé in Fedde, Rep. Spec. Nov. VIII. 285 (1910). — Nakai in Jour. Coll. Sci. Univ. Tokyo, XXXI. Add. 509 (Fl. Kor. pt. II.) (1911); Fl. Sylv. Kor. X. 46 (1921). — McKelvey, Lilacs, 507 (1928).

Korea. Kōgen Prov.: in monte des diamants, *U. Faurie,* no. 714, June 21, and no. 722, May 22, 1906 (syntypes; isotypes in A. A.).

This is closely related to *S. amurensis* Rupr., but readily distinguished by the lanceolate or oblong-lanceolate leaves short-pilose beneath along the midrib and the lower part of the lateral veins.

Osmanthus Delavayi Franchet in Bull. Soc. Linn. Paris, I. 613 (1886). — Léveillé in Cat. Pl. Yun-Nan, 181 (1916).

Ligustrum phillyrea Léveillé in Bull. Géog. Bot. XXV. 41 (1915); Cat. Pl. Yun-Nan, 181 (1916). — **Synon. nov.**

China. Yunnan: rochers moussus de Io-chan, 3200 m., *E. E. Maire,* May 1912, "sous-arbrisseau toujours vert, haut 0.20 m., fl. blanches" (syntype of *Ligustrum phillyrea;* photo. in A. A.); brousse de montagnes à Pe-long-tsin, 3200 m., *E. E. Maire,* May 1912 (syntype of *Ligustrum phillyrea;* ex Léveillé); haut plateau de Ta-hai-tse, 3200 m., *E. E. Maire,* May [1912], "petit arbre à feuilles persistantes, fl. blanches" (on same sheet with the specimen from Io-chan).

Ligustrum phillyrea has been identified with *Osmanthus Delavayi* in the Herbarium at Edinburgh according to a note on the cover of the specimen. I have not seen the specimen from Pe-long-tsin. On the same sheet with the syntype from Io-chan there is another label cited above; the three branches on this sheet are in bloom and exactly alike, so that it is not possible to say which came from Io-chan and which from Ta-hai-tse.

Chionanthus retusa Lindley & Paxton in Paxton Flow. Gard. III. 85, fig. 273 (1853). — Nakai, Fl. Sylv. Kor. x. 16, t. 1, fig. a-c (1921).

Chionanthus retusa var. *Mairei* Léveillé in Fedde, Rep. Spec. Nov. XIII. 175 (1914); Cat. Pl. Yun-Nan, 179 (1916). — **Synon. nov.**

CHINA. Yunnan: environs de Tong-tchouan, 2700 m., *E. E. Maire,* May 1911 (holotype of *C. retusa* var. *Mairei;* ex Léveillé); rochers en face de Pi-ka-ting, 2500 m., *E. E. Maire,* May (1911-13).

I have not seen the holotype of Léveillé's variety, but another specimen from the Léveillé herbarium cited above, which bears in his handwriting the name given by Léveillé. There is also a specimen of *Ch. retusa* from Korea (Faurie no. 517) in the Léveillé herbarium which Léveillé has named in honor of the collector, but later reduced to a variety of *Ch. retusa* and apparently never published.

Chionanthus retusa var. **coreana** (Lévl.) Nakai in Tokyo Bot. Mag. XXXII. 115 (1918); Fl. Sylv. Kor. x. 17, t. 1, fig. d (1921).

Chionanthus coreanus Léveillé in Fedde, Rep. Spec. Nov. VIII. 280 (1910).

KOREA. Quelpaert: secus torrentes Htepyeng, rare, *E. Taquet,* no. 1515, May 5, 1908 (holotype of *Ch. coreanus;* isotype in A. A.).

This is perhaps best considered only a form of *Ch. retusa.* The species is very variable in the shape of its leaves which may vary in the typical form from emarginate to acute or sometimes slightly acuminate even on the same plant. In its oblong to oblong-lanceolate shape of the leaves the variety is rather distinct, but not all the leaves are as clearly acuminate as shown in Nakai's plate, part of them are obtuse or acute; Léveillé describes the leaves as ovate which does not agree with his measurements, and as obtusish which fits only part of the leaves.

Ligustrum lucidum Aiton, Hort. Kew ed. 2, I. 19 (1810). — Léveillé, Fl. Kouy-Tchéou, 295 (1914); Cat. Pl. Yun-Nan, 181 (1916). — Mansfeld in Bot. Jahrb. LIX. Beibl. 132, p. 49 (1924).

Ligustrum Esquirolii Léveillé in Fedde, Rep. Spec. Nov. x. 147 (1911); Fl. Kouy-Tchéou, 295 (1914). — Mansfeld in Bot. Jahrb. LIX. Beibl. 131, p. 72 (1924). — **Synon. nov.**

Esquirolia sinensis Léveillé in Fedde, Rep. Spec. Nov. x. 441 (1912).

Ligustrum lucidum var. *Esquirolii* Léveillé, Cat. Pl. Yun-Nan, 181 (1916).

CHINA. Kweichou: Lao-ten, *J. Esquirol,* no. 87, June 1904, "fl. blanches" (holotype of *L. Esquirolii;* photo. in A. A.); Pin-tchai, *J. Esquirol,* no. 1577, June 1909, "fl. blanches" (holotype of *Esquirolia sinensis* and *Ligustrum lucidum* var. *Esquirolii;* photo. in A. A.).

Esquirolia sinensis was identified by Léveillé himself with *Ligustrum lucidum* in his Flore du Kouy-Tchéou; two years later in his Cat. Pl. Yun-Nan he distinguished it as a variety of *L. lucidum,* but Mansfeld (l. c.) refers it to *L. lucidum* as a synonym.

Ligustrum japonicum Thunberg, Fl. Jap. 17, t. 1 (1784). — Nakai in Tokyo Bot. Mag. XXXII. 120 (1918); Fl. Sylv. Kor. x. 33, t. 10 (1921). — Mansfeld in Bot. Jahrb. LIX. Beibl. 132, p. 51 (1924).

Ligustrum Taquetii Léveillé in Fedde, Rep. Spec. Nov. x. 378 (1912).

KOREA. Quelpaert: in sylvis Hallaisan, *E. Taquet,* no. 3051, June 1909, "haut 7 à 8 m." (holotype of *L. Taquetii;* photo. in A. A.).

Ligustrum Taquetii has been referred to *L. japonicum* by Nakai and by Mansfeld, but differs from typical *L. japonicum* in the narrow, elliptic-oblong, cuneate, thin leaves. The specimen bears no coriaceous leaves of the previous year, as does all the other Quelpaert material before me, as Taquet nos. 1118, 1119, 1120, 3050, 3052 and 3054, Faurie 721 and 1871, and Wilson 9514, but the inflorescence and the flowers agree well with *L. japonicum*.

Ligustrum sinense Lour. var. **myrianthum** (Diels) Hoefker in Mitt. Deutsch. Dendr. Ges. XXIV. 57 (1915). — Mansfeld in Bot. Jahrb. LIX. Beibl. 132, p. 61 (1924).

Ligustrum Bodinieri Léveillé, Fl. Kouy-Tchéou, 295 (1914). — Mansfeld in Bot. Jahrb. LIX. Beibl. 132, p. 72 (1924).

CHINA. Kweichou: environs de Kouy-yang, bois de Kin-lin-chan et mont du Collège, *E. Bodinier,* no. 2249, May 15 and 18, 1898, "grand arbuste" (syntypes of *L. Bodinieri;* photo. in A. A.); item, route de Pin-yue à Kouy-yang, *L. Martin,* May 18, 1899 (locality given on label of no. 2249).

Ligustrum Bodinieri was identified as *L. sinense* var. *myrianthum* at the Herbarium in Edinburgh according to a note on the cover of the specimen. The type sheet contains two branches apparently from the two localities cited under no. 2249, while Martin's collection is not represented.

Ligustrum Quihoui Carrière in Rev. Hort. 1869, p. 377. — Mansfeld in Bot. Jahrb. LIX. Beibl. 132, p. 63 (1924).

Ligustrum Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 557 (Cat. Pl. Kiang-Sou, 17) (1916). — **Synon. nov.**

CHINA. Kiangsu: montagnes, *Ch. d'Argy* [1861-74] holotype of *L. Argyi;* photo. in A. A.).

Ligustrum Argyi has been identified at the Herbarium in Edinburgh with *L. Quihoui;* the name is not mentioned by Mansfeld.

Jasminum floridum Bunge in Mém. Div. Sav. Acad. Sci. St. Pétersb. II. 116 (Enum. Pl. China Bor. 42) (1833). — Kobuski in Jour. Arnold Arb. XIII. 147 (1932).

Jasminum Argyi Léveillé in Mem. Acad. Ci. Art. Barcelona, ser. 3, XII. 557 (Cat. Pl. Kiang-Sou, 17) (1916).

CHINA. K i a n g s u : Le-kien, *Ch. d'Argy,* May [1861-74] (holotype of *J. Argyi;* merotype in A. A.).

Jasminum humile Linnaeus, Spec. Pl. 7 (1753). — Kobuski in Jour. Arnold Arb. XIII. 150 (1932).

Jasminum Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 337 (1914); Cat. Pl. Yun-Nan, 179 (1916).

Jasminum Mairei var. *siderophyllum* Léveillé, Cat. Pl. Yun-Nan, 179 (1916).

CHINA. Y u n n a n : pâturages des mont à Peling-tsin; 3200 m., *E. E. Maire,* May 1913, "arbuste buissonant, haut 0.60 m., fl. jaunes inodores" (holotype of *J. Mairei;* merotype in A. A.); haut plateau de Tai-hai, 3200 m., *E. E. Maire,* July [1911-13], "arbuste buissonant, haut 0.60 m., fl. roses" (holotype of *J. Mairei* var. *siderophyllum;* merotype in A. A.).

Maire gives the color of the flowers of *J. Mairei* var. *siderophyllum* as rose, but this is apparently an error; the flowers of *J. humile* are always yellow.

Jasminum lanceolarium Roxb. var. **puberulum** Hemsl. in Jour. Linn. Soc. XXVI. 78 (1889). — Kobuski in Jour. Arnold Arb. XIII. 158 (1932).

Jasminum Dunnianum Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914); Fl. Kouy-Tchéou, 293 (1914).

CHINA. K w e i c h o u : Che-ten, *J. Esquirol,* no. 887, June 1906, "arbrisseau, fl. blanches" (holotype of *J. Dunnianum;* merotype in A. A.).

Jasminum sinense Hemsley in Jour. Linn. Soc. Bot. XXVI. 80 (1889). — Kobuski in Jour. Arnold Arb. XIII. 159 (1932).

Lonicera Rehderi Léveillé in Fedde, Rep. Spec. Nov. X. 145 (1911). — Non Merrill (1905).

Lonicera Cavalerici Léveillé, op. cit. XI. 31 (1912); Fl. Kouy-Tchéou, 63 (1914).

Jasminum Bodinieri Léveillé, op. cit. XIII. 151 (1914); Fl. Kouy-Tchéou, 293 (1914).

CHINA. K w e i c h o u : Pan-choui, route de Pin-fa à Tou-yun, *J. Cavalerie,* no. 3038, Apr. 9, 1907 (holotype of *Lonicera Rehderi* and *L. Cavaleriei;* merotype in A. A.); environs de Kouy-yang, mont du

Collège, rocailles, *E. Bodinier*, no. 1890, Sept. 11, 1898 (syntype of *J. Bodinieri*, ex Léveillé); environs de Tsin-gay, Gan-pin, *J. Laborde*, Sept. 1897, "arbuste sarmenteux, fl. jaunes" (syntype of *J. Bodinieri;* merotype in A. A.); environs de Tou-chan, *J. Cavalerie*, July 1897 (syntype of *J. Bodinieri;* merotype in A. A.).

Jasminum polyanthum Franchet in Rev. Hort. 1891, p. 270, fig. 69. — Léveillé in Fedde, Rep. Spec. Nov. XIII. 150 (1914). — Kobuski in Jour. Arnold Arb. XIII. 163 (1932).

Jasminum Blinii Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914); Cat. Pl. Yun-Nan, 179 (1916).

Jasminum Delafieldii Léveillé, Cat. Pl. Yun-Nan, 179 (1916).

CHINA. Kweichou: Gan-chouen, *J. Cavalerie*, no. 3912, May 1912, "liane, fl. blanchâtres" (syntype of *J. Blinii;* merotype in A. A.); Hin-y-hien, *E. Bodinier*, no. 1343, April 10-11, 1898 (syntype of *J. Blinii*, ex Léveillé; haies de Ma-tchang, près Tchen-lin, *J. Esquirol*, April 28, 1906 "très belle fleur en long festons aux haies, rosée à d'intérieur" (holotype of *J. Delafieldii;* photo. in A. A.). Yunnan: environs de Yun-nan-sen, March 18, 1897; plaine de Lo-pin-tchéou, April 7, 1897 (syntype of *J. Blinii;* ex Léveillé).

Jasminum Seguini Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914); Fl. Kouy-Tchéou, 294 (1914). — Kobuski in Jour. Arnold Arb. XIII. 165 (1932).

CHINA. Kweichou: rochers de la cascade aux environs de Hoang-ko-tchou, *J. Seguin* in herb. *Bodinier*, no. 2354, June 9, 1898, "arbuste liane, fl. blanches" (holotype of *J. Seguini;* merotype in A. A.).

Jasminum Duclouxii (Lévl.), comb. nov.

Melodinus Duclouxii Léveillé in Fedde, Rep. Spec. Nov. II. 114 (1906).

Jasminum Schneideri Léveillé in Monde Pl. sér. 2, XVIII. 31 (1916).

Jasminum dumicolum W. W. Smith in Notes Bot. Gard. Edinb. XII. 207 (1920). — Kobuski in Jour. Arnold Arb. XIII. 166 (1932).

CHINA. Yunnan: environs de My-tsao, *F. Ducloux*, no. 112, March 4, 1897, "tiges s'enlaçant aux arbres et buissons, fl. blanches, boutons roses" (holotype of *Melodinus Duclouxii* and *J. Schneideri;* photo. in A. A.); Shweli valley, *G. Forrest*, no. 7926, Shweli-Salween divide, *Forrest*, no. 9346; east of Teng-yueh, *Forrest*, no. 8094; Ma-chang-kai valley, *Forrest* no. 9757 (all syntypes of *J. dumicolum;* isotypes in A. A.).

In the original description of *Melodinus Duclouxii* the species is credited to Kweichou, but My-tsao is apparently in the province of Yunnan. The species is not cited either in the Flore du Kouy-Tchéou or in the

Catalogue des plantes du Yun-Nan. In Monde des plantes (l. c.) Léveillé changed the name *Melodinus Duclouxii* to *Jasminum Schneideri*. On the label of the type-specimen the plant was named *Jasminum* in Ducloux's handwriting; this was crossed out and corrected to *Melodinus* by a different hand, but without specific epithet, and under it appears in Léveillé's handwriting *Jasminum Schneideri* Lévl.

Jasminum Prainii Léveillé in Fedde, Rep. Spec. Nov. x. 148. (1911); XIII. 150 (1914); Fl. Kouy-Tchéou, 294 (1914). — Kobuski in Jour. Arnold Arb. XIII. 167 (1932).

CHINA. K w e i c h o u : route de Pin-fa à Ou-glan, *J. Cavalerie*, Aug. 1908 (holotype; merotype in A. A.).

Jasminum Beesianum Forrest & Diels in Notes Bot. Gard. Edinb. v. 253 (1912). — Léveillé, Fl. Kouy-Tchéou, 293 (1914); in Fedde, Rep. Spec. Nov. XIII. 149 (1914); Cat. Pl. Yun-Nan, 179 (1916). — Kobuski in Jour. Arnold Arb. XIII. 168 (1932).

Jasminum Valbrayi Léveillé in Fedde, Rep. Spec. Nov. XIII. 337 (1914).

CHINA. Y u n n a n : haies, plaine de Tong-tchouan, 2500 m., *E. E. Maire*, May 1913, "arbuste delicat, grimpant, rameaux verts, long 1 à 2 m., fl. d'un rouge carmin" (holotype of *J. Valbrayi;* isotype in A. A.).

Jasminum Valbrayi was already referred as a synonym to *J. Beesianum* by Léveillé in his Catalogue des plantes du Yun-Nan.

Jasminum multiflorum (Burm. f.) Andrews, Bot. Repos. VIII. t. 496 (1807). — Kobuski in Jour. Arnold Arb. XIII. 172 (1932).

Jasminum Esquirolii Léveillé in Fedde, Rep. Spec. Nov. x. 147 (1911); Fl. Kouy-Tchéou, 293 (1914).

CHINA. K w e i c h o u : Hang-tong, *J. Esquirol,* no. 729, Jan. 25, 1906 (holotype of *J. Esquirolii,* ex Léveillé); without precise locality, *J. Esquirol,* no. 949, June 1906, "arbrisseau, fl. blanches" (cited in Fl. Kouy-Tchéou; duplicate in A. A.).

Jasminum amplexicaule Buchanan-Hamilton in Wallich, Num. List. 2853 (1930). — D. Don, Gen. Syst. IV. 60 (1837). — Kobuski in Jour. Arnold Arb. XIII. 173 (1932).

Jasminum laurifolium var. *villosum* Léveillé in Fedde, Rep. Spec. Nov. XIII. 151 (1914); Fl. Kouy-Tchéou, 294 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : gorges du fleuve Hoa-kiang, bord de la route à mi-côte, *E. Bodinier,* April 22, 1897, "arbuste à branches allongées, fleurs blanches" (holotype of *J. laurifolium* var. *villosum;* photo. in A. A.).

The leaves of *J. laurifolium* var. *villosum* are not truncate to subcordate as in typical *J. amplexicaule*, but rounded to broadly cuneate, as in the type of *J. aristatum* Wall. (no. 2853) which is referred as a synonym to *J. amplexicaule* and of which I have a photograph before me; the habit is also very much like that specimen except that the flowers at the end of the lateral branchlets are solitary. The branchlets are only slightly short-pubescent, but the under side of the leaves is loosely covered with short accumbent hairs as in Ford's specimen from Hainan distributed as *J. undulatum*.

LOGANIACEAE

Gardneria multiflora Makino in Tokyo Bot. Mag. VI. 33 (1892), nomen nud.; XV. 103 (1901). — Léveillé, Cat. Pl. Yun-Nan, 171 (1916).

Sabia Esquirolii Léveillé in Fedde, Rep. Spec. Nov. IX. 457 (1911); Fl. Kouy-Tchéou, 379 (1915). — **Synon. nov.**

Paederia Bodinieri Léveillé in Fedde, Rep. Spec. Nov. XIII. 179 (1914).

Marlea Cavaleriei Léveillé, Fl. Kouy-Tchéou, 116 (1914). — **Synon. nov.**

Rhamnus Pasteuri Léveillé, Monde Pl. sér. 2, XVIII. 31 (1916). — **Synon. nov.**

Gardneria chinensis Nakai, Trees Shrubs Jap. I. 316 (1922), nomen: in Tokyo Bot. Mag. XXXVIII. 45 (1924). — **Synon. nov.**

CHINA. K w e i c h o u : sur les rochers, *J. Esquirol*, no. 416, June 1905, "arbrisseau, fl. jaune" (holotype of *Sabia Esquirolii;* merotype in A. A.); Kouy-yang, dans la rocaille de la grotte de la grenouille, *E. Bodinier* no. 2616, June 13, 1899 (syntype of *Paederia Bodinieri* and of *Marlea Cavaleriei;* photo. in A. A.); Pin-fa, rochers près Ouen-pi, *J. Cavalerie*, no. 10bis, May 30, 1902 (syntype of *Paederia Bodinieri* and of *Marlea Cavaleriei;* photo. in A. A.); Kouy-yang, mont du Collège, grandes rocailles, *E. Bodinier*, no. 2315, June 9, 1898, "arbuste à tiges allongées lianeuses, fl. jaunes" (holotype of *Rhamnus Pasteuri;* merotype in A. A.).

Paederia Bodinieri was transferred by Léveillé to *Marlea* as *M. Cavaleriei*, because there exists an older *M. Bodinieri* Lévl.

I cannot find any good specific differences between *G. chinensis* Nakai and the Japanese *G. multiflora* Makino; the ample Chinese material before me shows great variability in the characters mentioned by Nakai and there seems to be no reliable character to separate it from typical *G. multiflora*.

Buddleia asiatica Loureiro, Fl. Cochinch. 72 (1790). — Léveillé, Fl. Kouy-Tchéou, 261 (1914). — Marquand in Kew Bull. Misc. Inform. 1930, p. 195.

Vitex Esquirolii Léveillé, Fl. Kouy-Tchéou, 443 (1915). — **Synon. nov.**

CHINA. Kweichou: Lo-fou, jardin Église, alt. 800 m., *J. Esquirol*, no. 3536, Feb. 1912 (holotype of *Vitex Esquirolii;* photo. and merotype in A. A.).

Vitex Esquirolii was first identified with *Buddleia asiatica* by W. W. Smith according to a note on the type sheet. The synonym is not mentioned by Marquand.

Buddleia acutifolia C. H. Wright in Kew Bull. Misc. Inform. 1896, p. 24. — Marquand in Kew Bull. Misc. Inform. 1930, p. 203.

Buddleia Mairei Léveillé in Fedde, Rep. Spec. Nov. XIII. 258 (1914); Cat. Pl. Yun-Nan, 171 (1916).

CHINA. Yunnan: Mo-tsou, 600 m., *E. E. Maire*, May 1911 (holotype of *B. Mairei;* merotype in A. A.).

Buddleia Mairei was first identified with *B. acutifolia* by Marquand (l. c.).

Buddleia acutifolia f. **albiflora** (Lévl.), comb. nov.

Buddleia Mairei f. *albiflora* Léveillé, Cat. Pl. Yun-Nan, 171 (1916).

YUNNAN: without citation of locality and collector.

There is no specimen named *B. Mairei* f. *albiflora* in the Herb. Léveillé.

Forms of *B. acutifolia* with white flowers have been collected in Yunnan near Tali-fu by G. Forrest (no. 2) and near Yunnan by C. Schneider (no. 45); near Lung-chou, Kwangsi, by Morse (nos. 466, 467), and in Upper Burma by Shaik Mokin (no. 63 in Herb. Hort. Calcutt.).

Buddleia tibetica W. W. Sm. var. **truncatifolia** (Lévl.) Marquand in Kew Bull. Misc. Inform. 1930, p. 205 (1930).

Buddleia truncatifolia Léveillé in Fedde, Rep. Spec. Nov. XIII. 342 (1914); Cat. Pl. Yun-Nan, 171 (1916).

CHINA. Yunnan: haies, vallon de Kiao-tche-keou, 2550 m., *E. E. Maire*, Apr. 1903, "arbuste fragile, feuilles laineuses blanches, fl. roses" (holotype; merotype in A. A.).

APOCYNACEAE

Determined by R. E. WOODSON, JR.

Trachelospermum axillare Hooker f., Fl. Brit. Ind. III. 668 (1882). — Léveillé, Fl. Kouy-Tchéou, 31 (1914).

Melodinus Chaffanjoni Léveillé in Fedde, Rep. Spec. Nov. II. 114 (1906).

Maesa scandens Léveillé in Fedde, Rep. Spec. Nov. X. 375 (1912); Fl. Kouy-Tchéou, 286 (1914). — **Synon. nov.**

Periploca astacus Léveillé, Fl. Kouy-Tchéou, 43 (1914).

China. Kweichou: precise locality lacking, *J. Esquirol,* no. 399, June, 1905, "arbrisseau grimpante; fls. roses, sans odeur" (holotype of *Maesa scandens;* merotype in A. A.); Ma-jo, *J. Cavalerie,* no. 2972, July, 1900 (fruiting holotype of *Periploca astacus;* merotype in A. A.); environs de Kouy-yang, mont du Collège, *J. Chaffanjon,* no. 2302, June 9, 1898, "liane ligneuse; fleurs blanches" (holotype of *Melodinus Chaffanjoni;* photo. in A. A.).

Trachelospermum axillare is a rather frequent liana from northeastern India (Sikkim) to southeast-central China (Hupeh), under which Léveillé himself reduced to synonymy his *Melodinus Chaffanjoni* in Fl. du Kouy-Tchéou, 31 (1914). The synonymy of *Periploca astacus* was first discovered by C. K. Schneider in Sargent, Pl. Wilson. III. 335 (1916).

Trachelospermum gracilipes Hooker f., Fl. Brit. Ind. III. 668 (1882).

Melodinus Cavalerici Léveillé in Fedde, Rep. Spec. Nov. II. 113 (1912).

Trachelospermum rubrinerve Léveillé, Fl. Kouy-Tchéou, 32 (1914). — **Synon. nov.**

Trachelospermum gracilipes Hook. f. var. *Cavalerici* (Léveillé) Schneider in Sargent, Pl. Wilson. III. 332 (1916). — **Synon. nov.**

Trachelospermum divaricatum (Thunb.) Kanitz var. *brevisepalum* Schneider in Sargent, Pl. Wilson. III. 338 (1916). — **Synon. nov.**

China. Kweichou: environs de Tou-chan, *J. Cavalerie,* June 3, 1899 (holotype of *Melodinus Cavaleriei;* merotype and photo. in A. A.); Kouy-yang, mont du Collège, *J. Chaffanjon,* April, 1898 (holotype of *Trachelospermum rubrinerve;* merotype in A. A.).

Trachelospermum gracilipes occurs from northeastern India to southeast-central China (Hupeh) upon the continent of Asia, and also upon Formosa and the Liu-kiu Islands. In spite of the wide range, its characters appear too stable to permit varietal segregation at present. Schneider in Sargent, Pl. Wilson. III. 337 (1916) sought to distinguish *T. gracilipes* and *T. divaricatum* upon a fancied slight difference in length of the calyx-lobes, but was obliged to except *T. divaricatum* var. *brevisepalum* in his key to species. A revision of the Asiatic species of *Trachelospermum* is in preparation by the present writer.

Trachelospermum Dunnii Léveillé, Fl. Kouy-Tchéou, 31 (1914); Schneider in Sargent, Pl. Wilson. III. 340 (1916).

Melodium Dunnii Léveillé in Fedde, Rep. Spec. Nov. IX. 453 (1911). sphalm.

Melodinus Dunnii Léveillé, Fl. Kouy-Tchéou, 31 (1914), *in synon.*

China. Kweichou: without locality, *J. Cavalerie* (holotype; merotype in A. A.); Pin-fa, bois de Si-tchéou-gai, *J. Cavalerie,* no. 558,

Sept. 29, 1902 (photo. in A. A.); Pin-fa, *J. Cavalerie*, no. 344, Aug. 31, 1902 (photo. in A. A.); environs de Kouy-yang, mont du Collège, *J. Chaffanjon* in hb. *Bodinier*, April 25, 1898 (fragment and photo. in A. A.); the three last specimens are cited in Fl. du Kouy-Tchéou.

Trachelospermum Dunnii forms a very distinctive element of the genus *Trachelospermum* because of its general, ferruginous indument.

Trachelospermum Bodinieri (Léveillé) Woodson, comb. nov.

Melodinus Bodinieri Léveillé in Fedde, Rep. Spec. Nov. II., 113 (1912). — **Synon. nov.**

Trachelospermum cathayanum C. K. Schneider in Sargent, Pl. Wilson. III. 333 (1916). — **Synon. nov.**

CHINA. Kweichou: environs de Kouy-Yang, mont. du Collège, *J. Chaffanjon*, no. 2267, May 15, 1898, "liane sous-ligneuse; fleurs blanches" (holotype of *Melodinus Bodinieri;* photo. in A. A.).

This species is one of the most frequently distributed of the genus from southeastern China, and the type specimen (Chaffanjon 2267) agrees closely with that of *T. cathayanum* (Wilson 2348). Unfortunately, several others of the specimens ascribed to *T. cathayanum* by Schneider at the time of original publication are more correctly referable to other species, notably *T. jasminoides* (Lindl.) Lem., *T. crocostomum* Stapf, and *T. gracilipes* Hook. f.

Arduina Carandas (L.) K. Schumann in Engler & Prantl, Nat. Pflanzenfam. IV-2, p. 127 (1895).

Damnacanthus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. X. 435 (1912); Cat. Pl. Yun-Nan, 245 (1915). — **Synon. nov.**

CHINA. Yunnan: Kouai-tien, *J. Esquirol*, no. 1508, May 16, 1909 (holotype of *Damnacanthus Esquirolii;* merotype in A. A.).

This species, superficially somewhat reminiscent of the rubiaceous *Damnacanthus*, does not appear to be as frequent in southeastern China as in the adjacent mountains of India. It is notoriously variable.

Wrightia Schlechteri Léveillé in Fedde, Rep. Spec. Nov. XI. 67 (1912); Fl. Kouy-Tchéou, 32 (1914).

CHINA. Kweichou: ruisseau de La-jong, *J. Esquirol*, no. 111, June, 1904, "fleur jaune foncée" (holotype; merotype in A. A.).

This species is referable to the section *Bammatophyton* A. DC. of *Wrightia*. The flowers are dull yellow, with a remarkable corona consisting of five antepetalous oblanceolate-elliptic segments, narrowly acute, entire or subentire, 8-9 mm. long, and five alternating segments, deeply subulate-bifid, 1.5-2.0 mm. long, which are necessary to separate the plants properly from *W. pubescens* R. Br. Apparently the closest

relative of *W. Schlechteri* is *W. sikkimensis* Gamble, which bears scarlet flowers with a somewhat different corona.

Melodinus khasianus Hooker f., Fl. Brit. Ind. III. 629 (1882).

Trachelospermum Esquirolii Léveillé, Fl. Kouy-Tchéou, 32 (1912). — **Synon. nov.**

CHINA. K w e i c h o u : Tchéo-chou, *J. Esquirol,* no. 750, Aug. 1905, "arbrisseau, fleurs blanches" (holotype of *Trachelospermum Esquirolii;* merotype and photo. in A. A.).

The corolla-tube of this plant is very slightly longer than that of the typical representation of the species in northern India, but appears clearly conspecific.

Melodinus Seguini Léveillé in Fedde, Rep. Spec. Nov. II. 114 (1906); Fl. Kouy-Tchéou, 30 (1914).

Melodinus flavus Léveillé in Fedde, Rep. Spec. Nov. XI. 548 (1913). — **Synon. nov.**

Melodinus Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XI. 549 (1913). — **Synon. nov.**

Melodinus edulis Léveillé in Fedde, Rep. Spec. Nov. XI. 549 (1913); Fl. Kouy-Tchéou, 30 (1914). — **Synon. nov.**

CHINA. K w e i c h o u : cascade de Hoangko-chou, sur les rochers, *J. Séguin* in hb. *Bodinier,* no. 2390, June 9, 1898 (holotype of *Melodinus Seguini;* merotype and photo. in A. A.); Ché-ten, *J. Esquirol,* no. 886, June, 1906 (holotype of *M. Esquirolii;* photo. in A. A.); Lo-fou, Aug., 1909; Ly-po, Febr. 1900, *J. Cavalerie,* no. 3412 (holotype of *M. flavus;* in herb. Edinburgh; photo. in A. A.); Gan-chouen, rochers, *J. Cavalerie,* no. 3802 (two sheets, flowering and fruiting), July, 1910 (holotype of *Melodinus edulis;* merotype of flowering specimen and photos. in A. A.).

Much has been made of the faucal corona of *Melodinus* as a specific criterion. Consequently, it is fortunate that flowering material is relatively abundant upon the type sheets of three of Léveillé's species of the genus, now deposited in the herbarium of the Royal Botanic Garden at Edinburgh. Although superficially quite similar, and one might have been pardoned for almost immediately placing them together, a careful scrutiny recently was made of the faucal coronas of two or three flowers from the packets upon each sheet in an effort both to segregate these species if possible and to test the constancy of this character upon specimens of superficially identical aspect.

Two flowers were dissected from Esquirol 886, the type of *M. Esquirolii* Lévl. Within one flower seventeen corona segments were counted with the aid of a binocular dissecting microscope and a Silverman illu-

minator. The segments varied indefinitely from 0.05-0.17 cm. in length; entire, or occasionally bifid or trifid, and oblong-linear in shape. Within the other but twelve segments were found which were all entire, varying from 0.07-0.12 cm. in length. Two flowers also were examined from Cavalerie 3412, the type of *M. flavus* Lévl. The orifice of one bore eleven corona segments, linear-trigonal in shape and 0.12-0.6 cm. long; the other bore sixteen segments of nearly the same shape as those of the first, varying from 0.1-0.45 cm. in length. The segments of the first corona were found occasionally to bear a small tooth-like segment near the base. Within three flowers from Cavalerie 3802, the type of *M. edulis* Lévl. similar variability was manifest. The first corolla contained ten segments rather broadly oblong in shape, entire, and ranging from 0.08-0.12 cm. in length. The second bore twelve segments of roughly similar shape as those of the first, but with occasional, basal teeth as found in one specimen of *M. flavus*. These segments were 0.05-0.15 cm. long. The third flower was found to have twelve segments somewhat more narrowly oblong, entire, or with inconspicuous basal teeth, and 0.08-0.2 cm. long. Although the fragments of Séguin 2390, type of *M. Seguini* Lévl., were insufficient for detailed examination, the available material strongly supports classification with the preceding.

Quite recently another specimen of *Melodinus* has been collected in southern Szechuan (F. T. Wang 23181 in herb. Missouri Bot. Garden) which closely corresponds to the types of Léveillé's species of the same genus which have just been discussed, except with respect to the faucal corona, which consists merely of solitary and very obscure protuberances of unequal size and shape alternating with the corolla lobes. This writer is strongly inclined toward the position that Wang 23181 is referable to the polymorphic species *M. Seguini* Lévl.

With the range of variability of the faucal corona of *Melodinus* as elastic as it has been shown to be, from even the brief examination which has just been outlined, considerable doubt arises as to the use of this character as the basis for fine division of specific units. Nevertheless this criterion has been made the chief key character for the differentiation of ten species of the genus indigenous to French Indo-China by Pitard,[1] who is able to separate them by means of such features of the corona segments as whether present or absent; five or ten; free or united at the base; entire or divided; bifid or multifid, with an implication of regularity manifestly lacking in the four species of the genus discovered by Léveillé in closely neighboring southern China. An intensive evaluation of the species of *Melodinus* is much to be desired.

[1]Pitard in Lecomte, Fl. Gén. Indo-Chine, III. 1101 (1933).

Alstonia yunnanensis Diels in Notes Bot. Gard. Edinb. v. 165 (1912). — Léveillé, Cat. Pl. Yun-Nan, 10 (1915).

Acronychia Esquirolii Léveillé, Fl. Kouy-Tchéou, 374 (1915).

Alstonia Esquirolii Léveillé, Cat. Pl. Yun-Nan, 10 (1915). — **Synon. nov.**

China. Kweichou: ruisseau derrière Bo-ly et chemin de Kéou-tin, *J. Esquirol,* no. 3212, June, 1911 (holotype of *Acronychia Esquirolii;* merotype and photo. in A. A.); precise locality lacking, *J. Esquirol,* no. 740, Aug., 1905 (holotype of *Alstonia Esquirolii;* photo. and merotype in A. A.); Yunnan: sous bois, collines de Mi-tsao, alt. 2000 m., *E. E. Maire,* July, 1911-13, "arbuste, haut 1.20 m." (under *A. yunnanensis* in hb. Léveillé; fragment in A. A.).

Strangely enough, *Acronychia Esquirolii* and *Alstonia Esquirolii* bear no bibliographical relationship. Léveillé apparently realized the proximity of his *Alstonia Esquirolii* to *A. yunnanensis,* but suggested no differentia.

Alstonia Mairei Léveillé, Cat. Pl. Yun-Nan, 9 (1915).

Wikstroemia Hemsleyana Léveillé in Bull. Géog. Bot. xxv. 41 (1915). — **Synon. nov.**

China. Yunnan: rochers de Kiang-ti, alt. 2300 m., *E. E. Maire,* July, 1912, "arbuste, feuilles resistantes, fl. blanches" (holotype of *Alstonia Mairei;* merotype in A. A.); mont. de Mo-tsou, alt. 800 m., *E. E. Maire,* date lacking, "arbuste toujours verte, fl. blanches" (holotype of *Wikstroemia Hemsleyana;* merotype in A. A.).

Closely related to the preceding, but differing notably in the larger flowers and glabrous foliage. Both *A. yunnanensis* and *A. Mairei* are referable to the section Blaberopus of *Alstonia,* having a conspicuous, two-lobed disk, which about equals the ovary in the former, and is somewhat shorter in the latter species.

Aganosma cymosa (Roxb.) G. Don, Gen. Syst. iv. 77 (1838).

Echites cymosa Roxburgh, Fl. Ind. ii. 16 (1832).

Aganosma Schlechterianum Léveillé in Fedde, Rep. Spec. Nov. ix. 325 (1911). — **Synon. nov.**

Trachelospermum Navillei Léveillé, Fl. Kouy-Tchéou, 32, (1914). — **Synon. nov.**

China. Kweichou: rochers à Lao-ten, *J. Esquirol,* no. 100, June, 1904 (holotype of *Aganosma Schlechterianum;* merotype and photo. in A. A.); Lo-hou, buissons, alt. 900 m., *J. Esquirol,* no. 3653, June 1912 (holotype of *Trachelospermum Navillei;* merotype in A. A.).

Apparently rare in southeastern China, this species is of frequent occurrence in the closely neighboring provinces of India. Schneider

(Sargent, Pl. Wilson. III. 336. 1916) referred *T. Navillei* to *Aganosma cymosa* var. *elegans* Hook. f., a variety with purplish flowers from the Malay Peninsula. Léveillé expressly described the flowers of his species as white, coinciding with the typical variety of *A. cymosa* in this particular.

Sindechites Esquirolii (Léveillé) Woodson, comb. nov.

Parameria Esquirolii Léveillé in Fedde, Rep. Spec. Nov. IX. 325 (1911).

CHINA. K w e i c h o u : haies, precise locality lacking, *J. Esquirol,* no. 427, June, 1905, "fl. blanches" (holotype; merotype and photo. in A. A.).

This species differs from *S. Henryi* Oliv. in such characters as the smaller corolla with the tube scarcely three times exceeding the calyx lobes, the ovary nearly twice surpassing the nectaries, the anthers with narrow, subparallel auricles and linear, apical hair-tuft nearly as long as the anther proper inserted slightly below midway within the corolla tube, and the leaves with closer, subhorizontal venation. *Sindechites Henryi* is from the province of Hupeh.

Alyxia Schlechteri Léveillé in Fedde, Rep. Spec. Nov. IX. 453 (1911).

CHINA. K w e i c h o u : Lo-fou, rivière de l'ouest, sud de Tin-fan, bois, rochers au sud, *J. Cavalerie,* no. 1871, March, 1904 (holotype; merotype and photo. in A. A.).

Doubtfully distinct from *A. angustifolia* Ridl. which it antedates. Our fragments have been insufficient for critical comparison.

Alyxia Bodinieri (Léveillé) Woodson, comb. nov.

Daphne Bodinieri Léveillé in Fedde, Rep. Spec. Nov. XIII. 258 (1914).

Wikstroemia Bodinieri Léveillé, Fl. Kouy-Tchéou, 417 (1915).

CHINA. K w e i c h o u : environs de Tsin-gay à Tchao-se, bois rocailleux de la montagne, *J. Laborde,* no. 2700, Sept. 7, 1899, "fort arbuste à branches allongées, fl. jaunes" (holotype; merotype in A. A.); same locality, *J. Cavalerie,* no. 1202, July 1903 (cited in Fl. du Kouy-Tchéou; photo. in A. A.).

Near *A. pumila* Hook. f., differing in the pubescent inflorescence and somewhat larger foliage.

DOUBTFUL SPECIES

Trachelospermum Cavaleriei Léveillé, Fl. Kouy-Tchéou, 31 (1914), "*Cavaleri.*"

CHINA. K w e i c h o u : ouest de Lo-fou, pente de rivière, *J. Cava-*

lerie, no. 2643, "liane à suc abondant" (holotype; merotype and photo. in A. A.).

The type specimen, consisting of a short branch bearing a pair of linear-fusiform follicles and two leaves, is insufficient for critical determination. It appears unlikely that it represents a species of *Trachelospermum*, because of the unusual shape and venation of the foliage. It is tentatively suggested that it may be referable to the genus *Wrightia*. An annotation upon the original label suggests the possibility of *Sindechites Henryi* Oliv., a species with very different foliage. The fruit of *Sindechites* is unknown.

ASCLEPIADACEAE

Determined by R. E. Woodson, Jr.

Stephanotis yunnanensis Léveillé, Cat. Pl. Yun-Nan, 14 (1915).

China. Yunnan: sous-bois a Tchéou-kia-tse-tang, alt. 2550 m., *E. E. Maire*, June, 1911, "arbuste grimpante, fl. blanches à biseré violet" (holotype; merotype in A. A.).

Six species of the small-flowered section *Jasminanthes* (Blume) Hemsl. of *Stephanotis* are known from eastern Asia and the adjacent archipelagos, among which *S. yunnanensis* may be distinguished as follows:

Corona manifest, the lobes free, adnate to the anthers.
  Corona lobes not surpassing the anthers.
    Plants manifestly pubescent; corolla lobes equalling or surpassing the tube.
      Calyx lobes ovate, 5-7 mm. long; plants of southeastern China (Hongkong) ..... *S. chinensis* Champ.
      Calyx lobes linear, 10 mm. long; plants of the Liukiu Islands. *S. lutchuensis* Koidz.
    Plants glabrous or virtually so; corolla lobes much shorter than the tube; plants of southwestern China (Yunnan) *S. yunnanensis* Lévl.
  Corona lobes manifestly surpassing the anthers; plants of the Malay Peninsula ..... *S. parviflora* Ridl.
Corona not manifest.
  Corolla lobes equalling or surpassing the tube; plants of the Malay Peninsula ..... *S. Maingayi* Hook. f.
  Corolla lobes shorter than the tube; plants of Borneo *S. suaveolens* (Blume) K. Schum.

Marsdenia yunnanensis (Lévl.) Woodson, comb. nov.

Gongronema yunnanense Léveillé, Cat. Pl. Yun-Nan, 13 (1915).

China. Yunnan: broussailles des collines à Ku-long-tchang, alt. 800 m., *E. E. Maire*, date lacking, "arbuste grimpante, feuilles caduques, fl. blanche rosée" (holotype; merotype in A. A.).

This species finds its most obvious affinities with *M. lucida* Edgew., *M. oreophila* W. W. Smith, and *M. Griffithii* Hook. f., although it is probably most closely related to the first enumerated, differing notably in the few (3-5-)-flowered umbels, and broadly acute corona scales which are conspicuously surpassed by the hyaline tips of the anthers. The Asiatic species of *Marsdenia* are badly in need of a monographic treatment such as that of Rothe for the species of the western hemisphere.

Marsdenia Cavaleriei (Lévl.) Handel-Mazzetti, MS. in herb. Edinburgh, comb. nov.

Metaplexis Cavalerici Léveillé, Fl. Kouy-Tchéou, 42 (1914).

CHINA. Kweichou: Houa-liang, *J. Cavalerie*, no. 2155, June, 1904 (holotype; photo. in A. A.).

This species is remarkable because of the membranaceous texture of the ovate corona segments.

Hoya carnosa (L.) R. Brown in Mem. Wern. Soc. I. 27 (1809).

Hoya Lyi Léveillé, in Bull. Soc. Bot. France, LIV. 369 (1907). — **Synon. nov.**

CHINA. Kweichou: Tsien-sen-kiao, *J. Ly*, no. 1879, Nov., 1904 (syntype of *H. Lyi;* photo. in A. A.); Lo-pie, rocailles près du marché, *L. Martin & J. Séguin*, no. 1853, Oct. 7, 1897 (syntype of *H. Lyi;* photo. in A. A.).

Hoya Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XI. 298 (1912).

CHINA. Kweichou: Lo-fou, sur arbe, *J. Cavalerie*, no. 3484, March, 1909 (syntype; photo. in A. A.); au bac de Pia-ouai, pend en longues ficelles des rochers et des vieux troncs, *J. Esquirol*, no. 2801, May 20, 1912 (syntype; photo. in A. A.).

Either specimen is without flowers for dissection; consequently a decisive opinion cannot be rendered concerning this plant, the foliage of which resembles to some extent that of *H. nummularia* Dcne., with which it may be conspecific.

CONVOLVULACEAE

Porana sinensis Hemsley in Jour. Linn. Soc. Bot. XXVI. 167 (1890). — Schneider in Sargent, Pl. Wilson. III. 355 (1916).

Porana Esquirolii Léveillé in Fedde, Rep. Spec. Nov. IX. 444 (1911); Fl. Kouy-Tchéou, 114 (1914); Cat. Pl. Yun-Nan, 58 (1916). — **Synon. nov.**

Porana Delavayi Gagnepain & Courchet in Lecomte, Not. Syst. III. 153 (1915). — **Synon. nov.**

Vatica cordata Hu in Jour. Arnold Arb. XI. 225 (1930). — **Synon. nov.**[1]

CHINA. K w e i c h o u : without precise locality, *J. Esquirol,* no. 976 "fleur bleue (peut-être)" (holotype of *P. Esquirolii;* photo. in A. A.); rochers de Lao-ten, *J. Esquirol,* no. 50, May 20, 1904 (cited under *P. Esquirolii* in Fl. Kouy-Tchéou; duplicate in A. A.).

Porana Delavayi is apparently a glabrescent form of *P. sinensis* Hemsl. Léveillé cites it in his Catalogue des plantes de Yun-Nan as a synonym of his *P. Esquirolii* and enumerates under *P. Esquirolii* in his Flore du Kouy-Tchéou Cavalerie's no. 2386 which is one of the syntypes of *P. Delavayi.* The specimens enumerated by Schneider all belong to the glabrescent form which seems to be the common plant in central and western China. The pubescent type, *P. sinensis,* which is based on a specimen from Kwangtung (Ford, no. 290) I have seen only from Kweichou, where it has also been collected by Handel-Mazzetti (no. 10877), and from Kwangsi (R. C. Ching, no. 7426) distributed as *Vatica cordata* Hu. Of the glabrescent forms I have also seen a duplicate of Maire's specimen from Li-tse-pin, Yunnan, one of the syntypes of *P. Delavayi.* As the two forms are easily distinguished and seem to be geographically well separated, the type extending from Kwangtung through Kwangsi to Kweichou, while *P. Delavayi* ranges from Yunnan through Szechuan and Kweichou to Hupeh, the glabrescent variety may be separated as **P. sinensis** var. **Delavayi** (Gagnep.) Rehd., var. nov. To this variety also belongs Esquirol's no. 50 from Lao-ten; whether Cavalerie's no. 2386 belongs here or to the type, I am not sure, since I have not seen this number, but as Gagnepain enumerates it without comment under his *P. Delavayi* I assume that it represents the glabrescent variety.

Porana racemosa Roxburgh, Hort. Bengal. 13 (1814), nom. nud.; Fl. Ind. II. 41 (1824). — Schneider in Sargent, Pl. Wilson. III. 361 (1916). — Léveillé, Cat. Pl. Yun-Nan, 59 (1916).

Porana Gagnepainiana Léveillé, Cat. Pl. Yun-Nan, 58 (1916). — **Synon. nov.**

CHINA. Y u n n a n : haies de la plaine à Long-ky, 700 m., *E. E. Maire,* June 1912, "arbuste grimpante, fl. blanches" (holotype of *P. Gagnepainiana;* merotype in A. A.).

Argyreia Seguini Vaniot apud Léveillé, Fl. Kouy-Tchéou, 113 (1914); China Revue, 1916, p. 18 (MS.).

[1]The identification of *Vatica cordata* was communicated to me by Professor W. Y. Chun in a letter of Feb. 19, 1931, but I am not aware that this identification has been published.

Lettsomia Seguini Léveillé in Fedde, Rep. Spec. Nov. IX. 452 (1911).
Argyreia Seguini Vaniot in herb. ex Léveillé in Fedde, Rep. Spec. Nov. IX. 452 (1911), pro synon. *Lettsomiae Seguini.*

CHINA. K w e i c h o u : environs de Hoang-ko-chou, dans les rocailles, sur les rochers, *J. Seguin* in hb. *Bodinier,* no. 2438, July 9, 1898 "grande liane sous-ligneuse, bractées florales couleur de chair" (syntype of *Lettsomia Seguini;* photo. in A. A.), and no. 2438bis, Aug. 15, 1898 (syntype of *L. Seguini;* ex Léveillé); rocailles, descente du fleuve, *E. Bodinier,* no. 510, July 28, "liane, fl. blanches" (syntype of *L. Seguini;* photo. in A. A.); Lo-fou, *J. Cavalerie,* no. 3519, April and Aug. 1909 "couleur violette" (probably refers to the bracts) (syntype of *L. Seguini;* photo. in A. A.); route de Pien-yang à Lo-fou, *J. Cavalerie,* no. 2690, Nov. 1905 (syntype of *L. Seguini;* ex Léveillé); Oug-ray, *J. Esquirol,* no. 956, June 1906 "fl. blanche, panachée violet" (syntype of *L. Seguini;* photo. in A. A.).

With Seguin no. 2438 there is a description apparently written by Vaniot which was published with slight changes by Léveillé under *Lettsomia Seguini.*

Argyreia Seguini seems closely related to *A. argentea* Choisy and *A. bracteata* Choisy, but is easily distinguished from the former by the leaves being rounded at the base and glabrous above, by larger and broader pink bracts and white corolla appressed-pubescent outside; from the latter it differs in the leaves being quite glabrous above and villous-tomentose, not silky-strigose beneath, in the broader and larger pink bracts and in the white corolla being appressed-pubescent outside except below the middle of the tube, not hirsute to near the base.

BORAGINACEAE

Ehretia Dunniana Léveillé in Fedde, Rep. Spec. Nov. XI. 65 (1912); Fl. Kouy-Tchéou, 53 (1914).

CHINA. K w e i c h o u : Lo-fou, *J. Cavalerie,* no. 3479, March 1909 (holotype; photo. in A. A.).

Ehretia Dunniana is similar to *E. longiflora* Champ. but differs in the linear-oblong anthers about 1.75 mm. long, in the filaments shorter than the style, in the pubescent calyx and the more densely pubescent inflorescence.

VERBENACEAE

Callicarpa macrophylla Vahl, Symb. III. 13, t. 53 (1794). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 23 (Verben. China) (1932).

Callicarpa Dunniana Léveillé in Fedde, Rep. Spec. Nov. IX. 456 (1911).

Callicarpa macrophylla var. *Kouytchensis* Léveillé, Fl. Kouy-Tchéou, 440 (1915), sine descript. — **Synon. nov.**

China. Kweichou: environs de Hoang-ke-chou, vallée de Ko-lin-kiao (Tchen-lin), *J. Seguin* in hb. *Bodinier*, no. 2439, June 20, 1898, "arbuste à fleurs d'un violet-pourpre (syntype of *C. Dunniana;* photo. in A. A.); Long-chan *J. Esquirol,* no. 869, June 1906, "fleurs rouges" (syntype of *C. Dunniana;* merotype in A. A.); sud du Kouy-tchéou, *J. Cavalerie,* no. 2703, Nov. 1905, "1 à 2 m. de haut, fruit mûr d'un blanc de neige" (syntype of *C. macrophylla* var. *Kouytchensis;* photo. in A. A.); autour de l'église de Lo-fou, *J. Esquirol,* no. 3093, July, Sept. 1911, "fl. rouge, fruits blancs." (syntype of *C. macrophylla* var. *Kouytchensis;* photo. in A. A.).

Callicarpa Dunniana was first referred to *C. macrophylla* by P'ei, but no. 2439 in hb. Léveillé was already named *C. macrophylla* Vahl by Bodinier. On the label of his no. 2703 Cavalerie gives the following information: "plante de 1 à 2 m. de haut que les Chinois appellent jan-fau-houa (= teindre-riz-fleur), parce qu'il sen servent pour colorer leur gateaux de riz."

Callicarpa Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 456 (1911); Fl. Kouy-Tchéou, 439 (1915).

Callicarpa Seguini Léveillé in Fedde, Rep. Spec. Nov. IX. 455 (1911); Fl. Kouy-Tchéou, 440 (1915).

Callicarpa Feddei Léveillé in Fedde, Rep. Spec. Nov. X. 439 (1912); Fl. Kouy-Tchéou, 439 (1915).

Callicarpa Giraldiana Hesse var. *subcanescens* Rehder in Sargent, Pl. Wilson. III. 368 (1916). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 34 (Verben. China) (1932). — **Synon. nov.**

China. Kweichou: environs de Gan-pin, rochers, aux Grandes Rocailles, *L. Martin* in herb. *Bodinier,* no. 1996, Oct. 28, 1897, "fruits d'une belle couleur violacée" (syntype of *C. Bodinieri,* photo. in A. A.); environs de Gan-pin, torrent des Ligularia, *L. Martin* in herb. *Bodinier,* no. 2365, June 19, 1898, "arbuste, fl. violettes (syntype of *C. Bodinieri;* merotype in A. A.); Pin-fa, *J. Cavalerie,* no. 1095, June 23, 1923 (syntype of *C. Bodinieri;* photo. in A. A.); without precise locality, *J. Esquirol,* no. 468, June 1905 (holotype of *C. Feddei;* merotype in A. A.). Hupeh: without precise locality, *A. Henry,* no. 5864 (holotype of *C. Giraldiana* var. *subcanescens;* in Gray Herb.).

Callicarpa Bodinieri is the oldest name for that very variable species generally known as *C. Giraldiana* and agrees with its pubescent form described as var. *subcanescens.* The type of the latter is slightly more pubescent than Bodinier's no. 2365, one of the syntypes of *C. Bodinieri* and that which should be considered the type (lectotype) of the species, because it is from Bodinier's herbarium and is represented by ample flowering material, while no. 1996 is in fruit; the third syntype was col-

lected by Cavalerie and has the older leaves glabrescent, approaching those of var. *Giraldii*. *Callicarpa Feddei* hardly differs from the type except that the leaves are narrower and smaller. The type of *C. Giraldiana* var. *subcanescens* is somewhat more densely pubescent and agrees in this respect with *C. Seguini*. It seems hardly possible to draw a clear line between the pubescent type and the glabrescent var. *Giraldii*, since they are connected by intermediate forms; the densely pubescent var. *Lyi* is more distinct particularly in its pubescent corolla.

Callicarpa Bodinieri Lévl. var. **Lyi** (Lévl.), stat. nov.

Callicarpa Lyi Léveillé in Fedde, Rep. Spec. Nov. x. 439 (1912); Fl. Kouy-Tchéou, 439 (1915).

Callicarpa grisea Handel-Mazzetti in Anz. Akad. Wiss. Wien, 1921, p. 230 (Pl. Nov. Sin. Forts. 14, p. 4) (1921). — **Synon. nov.**

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 1026, June 3, 1903, "fleurs pourpres rouges" (holotype of *C. Lyi;* photo. and merotype in A. A.). Kwangsi: circa carbonis minas, 600 m., *Wang-Te-Hui*, Pl. Sin. cur. Handel-Mazzetti, no. 182, spring 1920 (holotype of *C. grisea;* isotype in A. A.).

This at the first glance looks like a distinct species with the grayish white tomentum of the under side of the leaves, of the stem and the inflorescence including the calyx and corolla, but in all other characters it agrees with typical *C. Bodinieri*. By P'ei it is referred to *C. Giraldiana* var. *subcanescens* as a synonym, but is easily distinguished by the much denser whitish pubescence, particularly the upper part of the corolla is fairly densely pubescent outside, while in the type only scattered stellate hairs are present or often entirely lacking.

Besides the specimens cited above W. P. Fang's no. 1235 from Szechuan and L. H. Bailey's specimens collected June 18, 1917 on the Chikungshan, Hupeh-Honan border, belong here.

Callicarpa Bodinieri Lévl. var. **Giraldii** (Rehd.), comb. nov.

Callicarpa Giraldii "Hesse" Rehder in Bailey, Stand. Cycl. Hort. II. 629 (1914).

Callicarpa Giraldiana Hort. Hesse apud Schneider, Ill. Handb. Laubholzk. II. 1048 (July 1912), nom. nud. — Hesse in Mitt. Deutsch. Dendr. Ges. XXI. 366, 2 figs. (after August 1912), sine descript. — Rehder in Sargent, Pl. Wilson. III. 366 (August 1916). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 23 (Verben. China) (1932).

Callicarpa Mairei Léveillé, Sert. Yunn. 2 (July 1916). — Cat. Pl. Yun-Nan, 297 (1917).

CHINA. Yunnan: forêts des coteaux à Tchen-fong-chan, 800 m., *E. E. Maire*, June 1912 "grande arbuste à feuilles persistentes, fl. jaunâtres" (holotype of *C. Mairei;* photo. in A. A.).

This is a glabrescent form of *C. Bodinieri*, while the preceding variety represents the extreme pubescent form of the species. *Callicarpa Bodinieri* var. *Giraldii* was based originally on cultivated specimens raised in the nursery of H. A. Hesse at Weener, Germany, from seed sent by G. Giraldi from Shensi or northern Hupeh. The first description appeared in 1914 as *C. Giraldii* (l. c.), though it had been mentioned as *C. Giraldiana* without description two years earlier by Schneider (l. c.) and in the same year a few months later photographs of flowering and fruiting branches were published by Hesse, but without description. A Latin description as *C. Giraldiana* appeared in 1916 in Plantae Wilsoniana (l. c.). Therefore the valid publication of the species as *C. Giraldii* dates from 1914, though the name *C. Giraldiana* has been generally adopted for it.[1]

Callicarpa Dielsii (Lévl.) P'ei in Mem. Sci. Soc. China, I. no. 3, p. 37 (Verben. China) (1932).

Viburnum Dielsii Léveillé in Fedde, Rep. Spec. Nov. IX. 443 (1911); Fl. Kouy-Tchéou, 66 (1914).

CHINA. Kweichou: Pin-fa, *J. Cavalerie*, no. 385, Sept. 4, 1902 (holotype; photo. in A. A.).

This species is very close to the following, but differs chiefly in its pubescence of simple or nearly simple hairs.

Callicarpa rubella Lindl. var. **Hemsleyana** Diels in Bot. Jahrb. XXIX. 547 (1900). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 40 (Verben. China) (1932).

Callicarpa panduriformis Léveillé in Fedde, Rep. Spec. Nov. IX. 455 (1911); Fl. Kouy-Tchéou, 440 (1915).

CHINA. Kweichou: environs de Kouy-yang, mont du Collège, *J. Chaffanjon* in hb. *Bodinier*, no. 2341bis, May 1898, "grande arbuste" (syntype of *C. panduriformis;* photo. in A. A.); environs de Tsin-gay, haies, bois de la montagne, *J. Laborde* in hb. *Bodinier*, no. 2507, Nov. 20, 1898, "jolies baies rouges (syntype of *C. panduriformis;* photo. in A. A.).

Callicarpa panduriformis was first identified with *C. rubella* var. *Hemsleyana* by P'ei.

[1] **Callicarpa Bodinieri** var. **Rosthornii** (Diels), comb. nov.

Callicarpa longifolia var. *Rosthornii* Diels in Bot. Jahrb. XXIX. 548 (1900).

Callicarpa Giraldiana var. *Rosthornii* (Diels) Rehder in Sargent, Pl. Wilson. III. 367 (1916). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 37 (Verben. China) (1932).

This variety which has been found in Szechuan and Kwangsi differs from typical *C. Bodinieri* chiefly in its smaller and narrower leaves.

Callicarpa dichotoma (Lour.) Raeuschel, Nomencl. ed. 3, p. 37 (1797). — P'ei in Mem. Sci. Soc. China I. no. 3, p. 51 (Verben. China) (1932).

Callicarpa Taquetii Léveillé in Fedde, Rep. Spec. Nov. XII. 182 (1913). — **Synon. nov.**

KOREA. Quelpaert: in silvis, *E. Taquet,* no. 5876, July 1911 (holotype of *C. Taquetii;* merotype in A. A.).

Premna parvilimba P'ei in Mem. Sci. Soc. China I. no. 3, p. 62 (Verben. China) (1932).

Celastrus yunnanensis Léveillé, Cat. Pl. Yun-Nan, 32 (1915).

CHINA. Yunnan: rochers, pied des montagnes a Kiao-kiao, 400 m., *E. E. Maire,* June 1911, "arbuste feuilles persistantes, fl. roses" (holotype of *Celastrus yunnanensis;* photo. and merotype in A. A.).

Celastrus yunnanensis was first referred to *Premna* by the writer and later recognized as a distinct species by P'ei, who described it as *C. parvilimba,* since there exists already a *P. yunnanensis* W. W. Sm.

Premna Bodinieri Léveillé in Fedde, Rep. Spec. Nov. X. 440 (1912); Fl. Kouy-Tchéou, 443 (1915). — P'ei in Mem. Sci. Soc. China I. no. 3, p. 80 (Verben. China) (1932).

CHINA. Kweichou: gorges de Hao-kiang, à la descente à mi-cote, *E. Bodinier,* no. 1583, April 22, 1897, "arbuste à branches allongées, fl. blanches ou blanc-jaunes" (holotype; fragment in A. A.).

Premna puberula Pampanini in Nuov. Giorn. Bot. Ital. n. ser. XVII. 701 (1910). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 85 (Verben. China) (1932).

Premna Martini Léveillé in Fedde, Rep. Spec. Nov. X. 440 (1912); Fl. Kouy-Tchéou, 443 (1915).

CHINA. Kweichou: environs de Kouy-yang, plaine et montagne dans les haies, *E. Bodinier,* no. 2217, May 18 and 26, 1899, "petit arbuste, fl. jaunâtres" (holotype of *P. Martini;* photo. in A. A.).

Premna Martini was first referred to *P. puberula* by W. W. Smith according to a note on the type specimen.

Premna Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. X. 439 (1912); Fl. Kouy-Tchéou, 443 (1915). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 87 (Verben. China) (1932).

CHINA. Kweichou: Pin-fa, *J. Cavalerie,* no. 3101, July 2, 1907, "grande arbre, fl. jaune, sale" (holotype; merotype in A. A.).

Clerodendron Bungei Steudel, Nomencl. ed. 2, I. 382 (1840).

Clerodendron foetidum Bunge in Mem. Sav. Etr. Acad. Sci. St.

Pétersb. II. 126 (Enum. Pl. Chin. Bor. 52) (1833). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 138 (Verben. China) (1932). — Non D. Don.

Pavetta Esquirolii Léveillé in Fedde, Rep. Spec. Nov. XIII. 178 (1914); Fl. Kouy-Tchéou, 371 (1915).

CHINA. Kweichou: Tchéou-mao-tan, *J. Esquirol,* no. 805, July 30, 1905 (syntype of *Pavetta Esquirolii;* photo. in A. A.). Yunnan: vallée de Hong-lou, 600 m., *E. E. Maire,* June 1912 (syntype of *Pavetta Esquirolii*, photo. in A. A.).

Pavetta Esquirolii was referred to *Clerodendron Bungei* by the writer and also at Edinburgh according to an undated note on Maire's specimen and doubtfully placed under *C. foetidum* by P'ei.

Besides the characters mentioned by P'ei to distinguish *C. fragrans* and *C. Bungei* the calyx-teeth seem to present good character; they are lanceolate and long-acuminate in the former and triangular-ovate and acute in the latter.

Clerodendron japonicum (Thbg.) Sweet, Hort. Brit. 322 (1826). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 140 (Verben. China) (1932).

Clerodendron Darrisii Léveillé in Fedde, Rep. Spec. Nov. XI. 301 (1912).

Clerodendron Esquirolii Léveillé, l. c. 302 (1912), non p. 298.

Clerodendron Leveillei Fedde apud Léveillé, Fl. Kouy-Tchéou, 442 (1915).

CHINA. Kweichou: Lo-fou, *J. Cavalerie,* no. 3490, Aug. 1909 "arbre" (holotype of *C. Darrisii;* merotype in A. A.); route de Pe-tien à Lo-yen, *J. Esquirol,* no. 123, July 1904, "arbrisseau de 1-2 m., sans division, sommité ecarlate" (holotype of *C. Esquirolii;* merotype in A. A.).

Clerodendron Darrisii and *C. Esquirolii* are enumerated as synonyms of *C. Leveillei* Fedde by Léveillé in his Flore du Kouy-Tchéou, the name *C. Esquirolii* based on Esquirol's no. 123 having been changed to *C. Leveillei* Fedde on account of the homonym published a few pages ahead and based on Esquirol's no. 2802 which was referred by the writer to *Tacca Paxiana* Limpr. (see note by P'ei in Mem. Sci. Soc. China, I. no. 3, p. 162).

Clerodendron mandarinorum Diels in Bot. Jahrb. XXIX. 549 (1900). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 145 (Verben. China) (1932).

Clerodendron Bodinieri Léveillé in Fedde, Rep. Spec. Nov. IX. 325 (1911); Fl. Kouy-Tchéou 441 (1915).

Clerodendron Cavaleriei Léveillé in Fedde, Rep. Spec. Nov. X. 439 (1912).

Clerodendron Bodinieri var. *Cavaleriei* Léveillé, Fl. Kouy-Tchéou, 441 (1915).

CHINA. Kweichou: environs de Gan-pin, *L. Martin* in hb. *Bodinier,* no. 1721, July 27, 1897, "petit arbre, fl. blanches" (syntype of *C. Bodinieri,* merotype and photo. in A. A.); Kouy-yang, le long des ramparts et devant la chapelle, N. D. de Liesse, *C. Martin* in hb. *Bodinier,* no. 1721, Aug. 2, 1899 (syntype of *C. Bodinieri;* photo. in A. A.); Tchéou-pao-tong, *J. Esquirol,* no. 788, July 23, 1905 (syntype of *C. Bodinieri;* photo. in A. A.); Pin-fa, *J. Cavalerie,* nos. 70 and 167, July 19 and Aug. 12, 1902 (syntypes of *C. Cavaleriei;* photos. in A. A.); Pepiang, *J. Esquirol,* no. 3722, Aug. 20, 1912, "fleurs blanches" (cited under *C. Bodinieri* var. *Cavaleriei* in Fl. Kouy-Tchéou; duplicate in A. A.).

Clerodendron Bodinieri and *C. Cavaleriei* were first referred to *C. mandarinorum* by P'ei. This species has been collected in Kweichou also by Handel-Mazzetti (no. 10884), by Y. Tsiang, nos. 7374 and 8528) and by Steward, Chiao and Cheo (no. 730).

Caryopteris paniculata (Kurz) C. B. Clarke in Hooker f., Fl. Brit. Ind. IV. 597 (1885). — P'ei in Mem. Sci. Soc. China, I. no. 3, p. 176 (Verben. China) (1932).

Callicarpa Martini Léveillé in Fedde, Rep. Spec. Nov. IX. 455 (1911); Fl. Kouy-Tchéou, 440 (1915).

CHINA. Kweichou: environs de Hoang-ko-chou, bord du gave, *L. Martin,* no. 2562, Feb. 12, 1899 (holotype of *C. Martini;* photo. in A. A.); Hang-tong, *J. Esquirol,* nos. 304 and 754, Jan. 1905 (cited under *C. Martini* in Fl. Kouy-Tchéou; (photo. of no. 754 and merotype of no. 304 in A. A.).

Callicarpa Martini was first referred to *Caryopteris paniculata* by P'ei (l. c.). In Flore du Kouy-Tchéou Esquirol's numbers are cited as 304 and 654, but the second number should read 754, as it appears on the type specimen.

(To be continued)

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THE CAMBIUM AND ITS DERIVATIVE TISSUES NO. X. STRUCTURE, OPTICAL PROPERTIES AND CHEMICAL COMPOSITION OF THE SO-CALLED MIDDLE LAMELLA

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With two text figures and plates 110-113

INTRODUCTION

MUCH HAS BEEN WRITTEN during the last hundred years concerning the structure, the development, and the physical and chemical properties of the cell wall. A careful study of this literature reveals many varied and more or less contradictory points of view. For example, there is no consensus of opinion concerning the use of such terms as *intercellular substance, middle lamella, primary wall, secondary wall, tertiary wall,* etc. Each of them is employed in several fundamentally different senses and to designate entirely different structures. It is essential to clarify this situation, since the existing confusion results in serious discrepancies, not only in descriptive morphological work, but also in physiological, biophysical, and biochemical investigations.

WHAT CONSTITUTES THE SO-CALLED MIDDLE LAMELLA?

Von Mohl (18) and the earlier botanical investigators believed that the cells of the xylem and of other tissues are bound together by a refractive intercellular substance which differs from the cell walls in its solubilities and other properties. Subsequently, with the discovery of cell division and an altered viewpoint regarding the origin and development of cells, this refractive layer was referred to by Hofmeister (14), Sachs (22), and many other botanists, as the middle lamella. The cytological investigations of Treub (32), Strasburger (30), Timberlake (31), and Allen (1) ultimately led to the conclusion that the middle lamella originates between the halves of the split cell-plate and is, in fact, the first-formed membrane or partition wall, more or less modified in thickness and in chemical composition during tissue differentiation.

Most botanists have differentiated the middle lamella by its refractive character, its differential staining, or its solubility in macerating agents. Dippel (9) demonstrated, however, in the first edition of "Das Mikroskop" that the refractive layer, which appears more or less homogeneous in white light, consists of three distinct layers, i. e., two anisotropic layers and an intervening isotropic layer, *Fig. 5*. He designated the anisotropic layers as primary walls and the isotropic central layer as intercellular substance, the three layers combined constituting the middle lamella. More recently there has been a tendency, among certain investigators, to limit the term middle lamella to the putative isotropic layer. Thus, Ritter (19) has defined the middle lamella as "the isotropic peripheral layer of the cell wall, including the irregular masses of isotropic material commonly found where three or more cells adjoin." Van Iterson (33) similarly differentiates the central isotropic layer as the original or "true middle lamella" and refers to Dippel's middle lamella as the "compound middle lamella."

Mangin (15, 16) demonstrated that the middle lamella of soft tissues is composed of pectic substances, and that "pectose" is intimately associated with cellulose in cell walls which have not been modified by lignification, suberization, etc. He inferred, from macerations of meristematic tissues, that the original partition membrane is of pectic composition and that cellulose is first deposited during the process of secondary thickening. In recent years, Ritter (19), Harlow (12), and others have emphasized the fact that a large proportion of the lignin in wood is located in the middle lamella. Furthermore, Schorger (28) and Ritter (20) consider that the middle lamella is actually composed of lignin.[1]

In view of the existing confusion concerning what constitutes the so-called middle lamella and regarding its physical and chemical constitution, it seemed desirable to the writers to undertake an extensive investigation of various tissues in an endeavor to clarify the situation. In order to have a clear conception of the so-called middle lamella in the mature xylem, it is necessary to consider the conditions in the cambium and the changes which take place during tissue differentiation. The results of a detailed study of the cambium and of its differentiating and fully differentiated derivatives are recorded in the following pages.

[1]It should be noted in this connection, in view of various criticisms of botanical workers, that not only did Schacht (24), Strasburger (29), Dippel (10), and many other botanists subject sections of tissues to chemical treatments, but also that they were cognizant of the fact that the middle lamella of woody tissues is insoluble in concentrated sulphuric acid and in Schweizer's reagent.

MATERIAL AND METHODS

In our work on the cambium, the following species were studied:

1. Pinus Strobus L.
2. Juniperus virginiana L.
3. Thuja occidentalis L.
4. Robinia Pseudoacacia L.
5. Cladrastis lutea (Michx. f.) Koch
6. Fraxinus americana L.
7. Acer rubrum L.
8. Catalpa speciosa Warder
9. Liquidambar Styraciflua L.

Most of the original observations were made on *Pinus Strobus*, but every phase of the work was checked and rechecked on other species. In dealing with the cambium, it is essential to secure freshly collected material from living trees. This is due to the fact that cambial walls contract so much during dehydration that permanent preparations present a caricature of the original structure.

Transverse and longitudinal sections of the wood of more than 800 genera of gymnosperms and angiosperms were examined in polarized light. The following species were selected for subsequent microchemical investigation.

1. Pinus Strobus L.
2. P. radiata D. Don
3. Taxodium distichum (L.) Richard
4. Sequoia sempervirens Endl.
5. Libocedrus decurrens Torr.
6. Trochodendron aralioides Sieb. & Zucc.
7. Ulmus americana L.
8. Tilia glabra Vent.
9. Quercus agrifolia Née
10. Q. Douglasii Hook. & Arn.
11. Prosopis juliflora DC.
12. Citrus Limonia Osbeck
13. Betula papyrifera Marsh.
14. Populus grandidentata Michx.
15. P. trichocarpa Torr. & Gray
16. Nyssa sylvatica Marsh.
17. Robinia Pseudoacacia L.
18. Liquidambar Styraciflua L.
19. Catalpa speciosa Warder
20. Fraxinus mandshurica Rupr.

21. Rhizophora mangle L.
22. Myodocarpus simplicifolius Brong. & Gris
23. Protomegabaria Stapfiana Hutch.
24. Homalium guianense (Aubl.) Warb.
25. Brackenridgea Hookeri A. Gray
26. Tetramerista glabra Miq.

The last six species are tropical forms which were used for comparison with the species of warm-temperate and cold-temperate regions. Sections were made either from freshly collected wood or from seasoned wood soaked in cold water. No softening agents were employed, as these change the chemical properties of the cell walls.

In studying the optical properties of wood, thin and truly transverse sections of straight-grained specimens are essential. Most of the critical work with polarized light was done on sections 5 μ in thickness. Thicker or slightly oblique sections obscure the finer details and give much distorted images. Chemical tests were made on sections 5 to 15 μ in thickness, depending upon the ease with which the material could be cut.

THE CAMBIUM

Since 1900, most botanists have visualized the cambium as an extremely delicate and very thin-walled tissue. Such a conception is due largely to the study of fixed and dehydrated material and to unfamiliarity with the investigations of Sanio (23), Schacht (25), Strasburger (29), Dippel (10), and others who worked with freshly cut and undehydrated material. Sanio (23) demonstrated that the radial walls of the fusiform initials in the cambium of *Pinus sylvestris* are of considerable thickness and that those of adjacent cells are separated by an amorphous intercellular layer or "Zwischensubstanz." Sanio (23) and others erred, however, in their assumption that the occurrence of a "Zwischensubstanz" is an unusual phenomenon in meristems and involves the splitting of an originally entire and homogeneous partition membrane. If they had devoted more attention to the study of ray initials and to the cambia of dicotyledons, they might have recognized the fact that each initial is enclosed, *on all sides*, within a wall of its own which is separated from the walls of adjoining cells by more or less intercellular material. The cambial wall expands as the initial increases in size. The intercellular material is a plastic colloidal substance that passes readily into a semi-liquid phase, thus facilitating those movements and adjustments of cells which are such characteristic features of the actively growing cambium.[1]

[1]For a discussion of these and other phenomena and a description of techniques employed in studying the living cambium, the reader is referred to preceding papers of this series, Bailey (2, 3, 4), and Bailey and Zirkle (5).

In other words, the wall of the cambial initials is a discrete morphological structure which, once formed, maintains its identity under all conditions of growth and development, whereas the intercellular layer is passively molded into various forms and possesses few of the attributes of a true membrane.

Dippel (10) concluded, in the second edition of "Das Mikroskop," that the walls of the cambium are isotropic. He figured (Part II, page 573) a transverse section of the cambium and its derivatives as seen in polarized light with crossed nicols. The walls of the initials and of the enlarging derivatives are dark, whereas the "primary walls," formed during the later stages of the differentiation of the xylem and phloem, are brilliant. This was in line with Dippel's contention that the cambial walls—which are incorporated in the isotropic "intercellular substance" of mature tissues—are composed of "pectose," whereas the subsequently formed "primary walls" consist largely of cellulose.

In view of the accuracy of Dippel's delineations of polarized light pictures of mature tissues, which are much superior to those of recent workers, it is difficult to understand how he could have been led so far astray in his treatment of the cambium. *Figure 1* is a transverse section of the actively growing cambium of *Pinus Strobus,* photographed in polarized light with crossed nicols. Although there is a more intense anisotropy in the region of the xylem than in the cambial zone, the walls of the meristematic cells and of their enlarging derivatives obviously exhibit double refraction. *Figure 2* is a tangential longitudinal section of the cambium of *Fraxinus americana,* likewise photographed in polarized light with crossed nicols. It is evident that the walls of both ray initials and fusiform initials are birefringent. Furthermore, an examination of transverse and longitudinal sections of the cambia of a wide range of gymnosperms and angiosperms indicates that all cambial walls are anisotropic, but that the intensity of double refraction, angles of extinction, etc. vary somewhat from plant to plant. The anisotropy is not due to "rod" or "plate" double refraction, since the walls are birefringent even when they are saturated with a liquid of the same refractive index as their own (Frey, 11). The intercellular substance, on the contrary, is truly isotropic and is dark at all angles and in all planes of section. *Figure 3,* a highly magnified portion of a thin tangential, longitudinal section of the cambium of *Pinus Strobus,* shows the anisotropic walls of two adjacent fusiform initials and the dark isotropic intercellular material between them.

It should be noted, in this connection, that cambial walls are characterized by having more or less numerous plasmodesmata which may be

uniformly distributed or aggregated in thinner areas of the walls, i. e., in so-called primary pit-fields. These primary pit-fields are more closely approximated in the radial walls of the fusiform initials of most dicotyledons, *Figure 4,* than they are in the case of gymnosperms, *Figure 3.* Thus, the walls have a beaded appearance in sectional view, *Figures 2, 4,* and *11.* The intercellular material is much reduced in amount in the region of the primary pit-fields and between the tangential walls of the fusiform initials of gymnosperms, but its presence may be clearly demonstrated by adequate modern techniques.

Our investigations of the cambium indicate that the isotropic intercellular material is composed largely of polyuronides and contains little or no cellulose, and that the anisotropic cambial walls contain both cellulose and polyuronides. When freshly cut sections of the living cambium are subjected to standard chemical treatments used in the extraction of pectic compounds, e.g., ammonium oxalate or dilute acids followed by dilute alkalis, the intercellular material dissolves, leaving the dissociated cambial walls, which are anisotropic and give a typical blue color with chloro-zinc iodide or iodine and sulphuric acid. The dissociated cambial walls are insoluble in 30% sodium hydroxide, or after prolonged treatments in hot dilute acids followed by alkalis, but dissolve completely in such standard solvents of cellulose as 72% sulphuric acid or Schweizer's reagent. When freshly cut sections of the cambium are used, the walls are also completely soluble in 72% sulphuric acid which dissolves both cellulose and polyuronides, but when treated with Schweizer's reagent, there remains a swollen residue of the cambial walls which is isotropic and no longer produces a blue color with iodine and sulphuric acid. This residue stains intensely with ruthenium red[1] and disappears in standard solvents for pectic compounds.

The physical properties, chemical solubilities, and colorations with ruthenium red, chloro-zinc iodide, and iodine-sulphuric acid indicate, therefore, that cambial walls are composed of a mixture of cellulose and polyuronides, and that they are separated by intercellular material which consists largely, if not entirely, of polyuronides. In other words, our observations and analyses are in substantial agreement with those of Mangin (16), Carré and Horne (7), and many others who have dealt with other types of soft, unlignified tissues. Furthermore, we have worked, during the last two years, in close coöperation with Professor Ernest Anderson, who has extracted the polyuronides from the cambium and young phloem of *Robinia Pseudoacacia* and has determined that they are of a pectic nature.

[1]For a discussion of the significance of the ruthenium red reaction see page 340.

The walls of cambial initials are characterized, from a physiological point of view, by their capacity for growth and expansion and for undergoing various reversible changes, e.g., seasonal variations in thickness and in colloidal properties. During the resting season, the cambial walls tend to be thicker and to have the general properties of a firm gel, whereas during the active growing season, they appear to be thinner and more pliable.

TISSUE DIFFERENTIATION

The specific changes that the cambial walls undergo during the differentiation of the xylem and phloem vary markedly, depending upon the particular types of tissue cells that are to be formed. In the case of those parenchymatous elements of the phloem, which retain their capacity for growth and enlargement, the original cambial walls are but slightly modified in form and thickness during tissue differentiation, and no true secondary walls are formed (compare *Figures 10* and *11*).

On the contrary, in the case of tissue cells which undergo irreversible changes and form layers of true secondary wall thickening, the cambial walls and the intercellular material tend to become thinner and considerably modified in form during the process of cell enlargement. Vestiges of the original primary pit-fields and intervening thickenings may persist, however, in parts of cells which are not subjected to excessive expansion. Such vestiges are of common occurrence in the radial walls of the tracheids of most conifers and of the terminal wood parenchyma of many dicotyledons, *Figures 12* and *13*.

The enlargement of those derivatives of the cambium which form tracheids, fiber-tracheids, libriform fibers, and bast fibers involves an increase in the cross-sectional area of the cells and elongation due to apical sliding growth. The cambial wall expands as the cell increases in size, but layers of secondary thickening are not deposited until the cell has attained its mature diameter. As the cambial walls increase in surface area and decrease in thickness, the layer of intercellular material becomes so tenuous that it is difficult to differentiate it by the use of ordinary microscopical methods, except in the angular spaces where three or more cells adjoin. Lignification is initiated during the earlier stages of secondary wall formation, and, in the species studied by us, is first visible in the cambial walls and the intercellular substance. It spreads centripetally through the successively formed layers of the secondary wall. The lignification of the cambial walls is usually very intense, except in the pit-membranes and crassulæ; whereas that of the secondary layers is extremely variable, particularly in dicotyledons.

The difficulty of differentiating the cambial walls from the intercellular material is accentuated by lignification, which alters the staining reactions and the indexes of refraction of the three adjoining layers, and makes them appear as a single homogeneously refractive unit. Furthermore, although the cambial walls are clearly anisotropic during the period of cell enlargement, *Figure 1,* their anisotropy tends to be obscured after the initiation of secondary wall formation and of lignification.

During the transformation of sapwood into heartwood the walls may absorb more or less "Gerbstoffe" which further alters their solubilities, optical properties, and staining reactions. Similarly, during the seasoning of sapwood, the walls may become saturated with various substances that are contained in the vacuoles of the living cells or are produced by the dying protoplasts. Therefore, critical observations should be made, if possible, upon freshly cut sections of living sapwood.

THE MATURE SECONDARY XYLEM

As will be shown in a subsequent paper of this series, the secondary wall is exceedingly complex, from a morphological point of view. It varies greatly not only in different tissue cells, but also in homologous walls of different plants.

In the case of normal tracheids,[1] *Text figure 1,* the secondary wall consists of three layers:[2] (1) a relatively narrow outer layer (c), (2) a narrower inner layer (e), and (3) an intervening layer (d) of variable thickness. The narrow inner and outer layers are characterized by having their fibrils of cellulose oriented more nearly at right angles to the longer axis of the cell, whereas the intervening layer is characterized by having them arranged either longitudinally or diagonally. The secondary walls project inward and are not in contact with the cambial walls in those parts of the cell where bordered pits are formed, *Text figure 2.* The narrow inner and outer layers of the secondary wall come together in the rim formed about the pit-aperture.

When unstained sections of wood are examined in white light, *Figure 8,* the narrow outer layers of the secondary walls of adjoining tracheids tend to blend with the cambial walls and the intercellular substance, forming an apparently homogeneous refractive layer, i. e., the so-called middle lamella of Dippel and of other botanical writers. That this middle lamella is actually a compound structure may be determined by

[1]Excluding "Rotholz" tracheids and other specialized and peculiar types.
[2]We are not concerned here with the submicroscopic layering which is revealed by swelling the walls and by other drastic treatments.

a careful study of the layering in the bordered pit-pairs (compare *Figure 8* and *Text figure 2*) or by transferring the sections to liquids of varying indexes of refraction.

When unstained transverse sections of wood are examined in polarized light with crossed nicols, the images vary considerably, depending

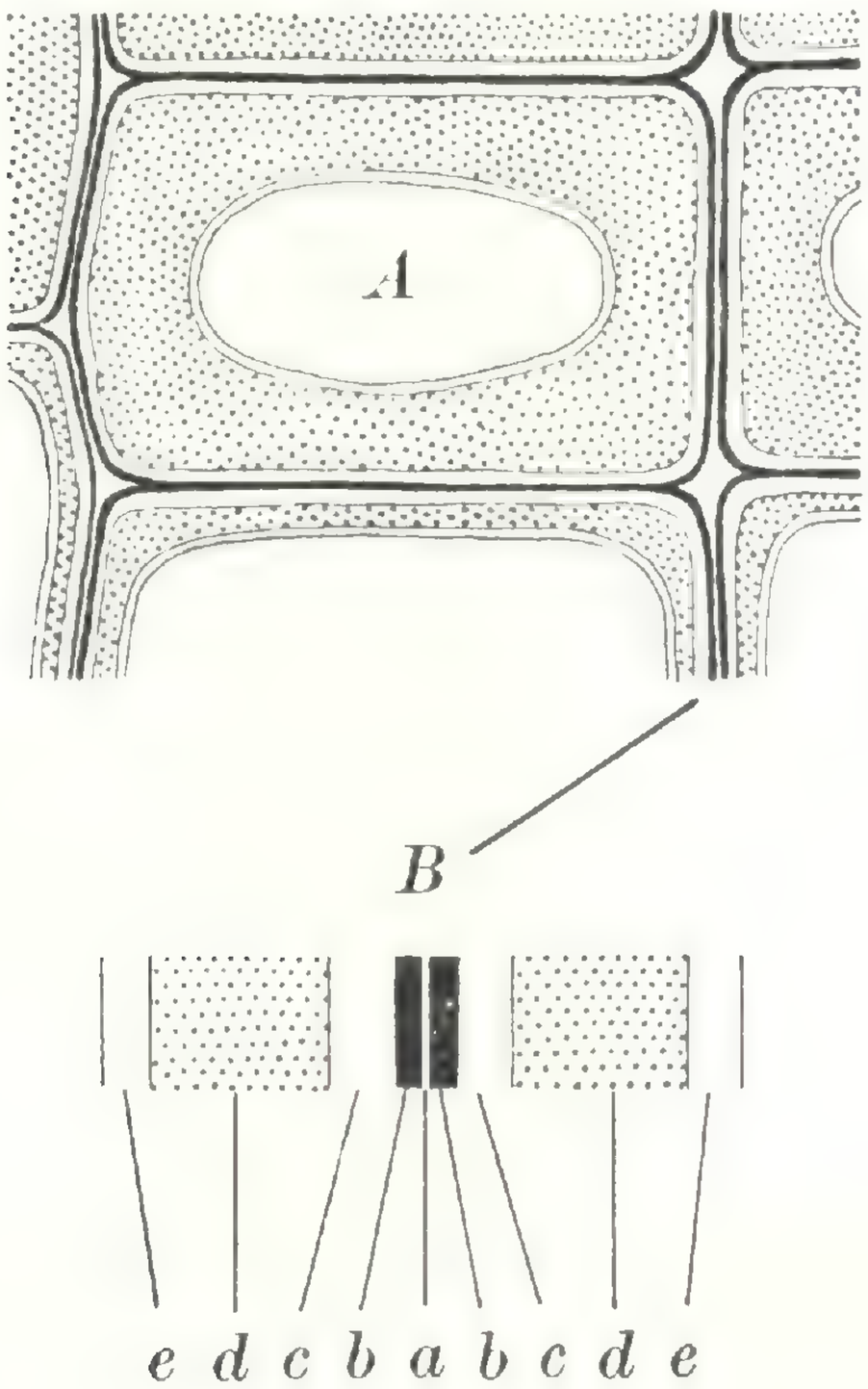

Figure 1

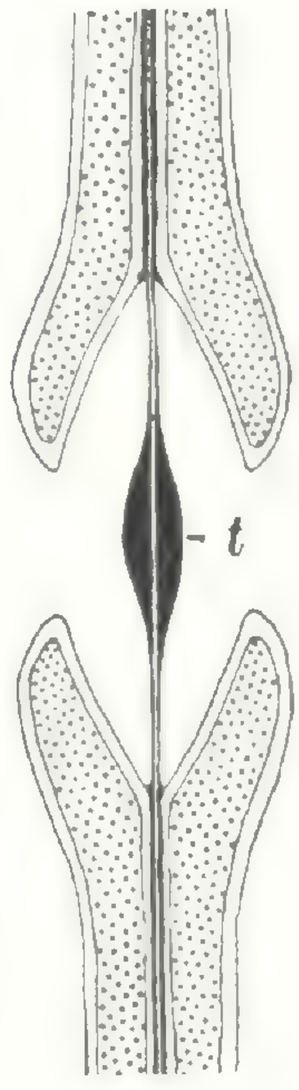

Figure 2

TEXT FIGURE 1. (A) Diagrammatic transverse section of one entire tracheid and of parts of seven others. (B) Section of adjacent walls more highly magnified; (a) truly isotropic intercellular substance, (b) cambial or primary wall, (c) outer layer of secondary wall, (d) central layer of secondary wall, (e) inner layer of secondary wall.

TEXT FIGURE 2. Diagrammatic bordered pit-pair in sectional view, showing pit-membrane, torus, and pit-apertures or openings in the secondary walls. Wall layers as in Text Fig. 1. t = torus or central thicker portion of the pit-membrane. The torus and the pit-membrane are composed of two cambial walls and of intercellular material.

upon a number of fluctuating factors. The narrow inner and outer layers of the secondary wall exhibit double refraction and are brilliant, *Figure 9*, whereas the central layer of the secondary wall is dark or less birefringent.[1] In other words, the phenomena observed between crossed

[1]The conditions tend to be reversed in longitudinal sections.

nicols are closely correlated with the orientation of cellulose micellæ. Where these are arranged parallel to the long axis of a tracheid, a layer appears dark in cross sections; where they are oriented nearly at right angles, a layer is brilliant. The brightness varies at intervening angles.

The closely approximated outer layers of the secondary walls of adjoining cells allow so much light to get by the crossed nicols that they fog or obscure, *Figure 9,* the three tenuous intervening layers, except in extremely thin sections, *Figures 5* and *6*. But in the case of the latter sections, the cambial walls and the intercellular material appear as a single isotropic layer, i. e., Dippel's intercellular substance, the so-called middle lamella of Van Iterson, Ritter, and others. The isotropic aspect of the cambial walls is due largely to the fact that they are so feebly anisotropic in comparison with the brilliant outer layers of the adjoining secondary walls, that they appear dark in contrast to them. Therefore, it is difficult to demonstrate the anisotropy of cambial walls when they are in contact with secondary walls, except under favorable circumstances. In the case of the mature xylem, the best material for this purpose occurs in those cells or portions of cells in which the cambial walls do not thin down excessively during tissue differentiation. Thus, in *Figure 7,* the feebly anisotropic cambial walls are visible between the brilliant outer layers of the secondary walls. By treating thin sections of the mature xylem with 65% phosphoric acid or diluted Schweizer's reagent, there is sufficient swelling so that it is possible to see the cambial walls as an anisotropic entity distinct from the outer layers of the secondary walls.

When woods are prepared for sectioning by the usual procedure of boiling in water and softening in hydrofluoric acid, the staining of sections with ruthenium red or with Haidenhain's haematoxylin produces the general appearance illustrated in *Figure 19*. The cambial walls and the intercellular material react as a unit—i. e., the so-called middle lamella or primary wall of various botanical writers—and stain more intensely in ruthenium red and haematoxylin than do the three layers of the secondary wall which react as another unit. It is possible to differentiate this homogeneously-staining so-called middle lamella into its constituent layers, not only by optical methods but also by chemical methods and differential staining. Thus, when sections of freshly cut wood, or of seasoned wood soaked in cold water, are treated with solvents for removing polyuronides, the cambial walls may be stained without appreciably coloring either the secondary walls or the intercellular material, *Figure 20*. By accurately controlled delignification, followed by treatment in Schweizer's reagent, it is possible to dissolve both the inter-

cellular material and the secondary walls, leaving the cambial walls intact, *Figure 15*. Owing to the fact that they may be unlignified, such minute and delicate structures as tori and pit-membranes may be resolved into their constituent layers by the use of solvents for polyuronides, *Figures 17* and *18*.

As shown by Harlow (13), the residues which remain after treating sections of wood with 72% sulphuric acid and subsequently boiling in 3% sulphuric acid, vary considerably in different species, depending upon the intensity of lignification. In the case of the dicotyledons, the secondary walls of the tracheids and fiber-tracheids frequently dissolve or disintegrate into a finely granular residue, whereas the more intensely lignified walls of the vessels do not, *Figure 14*. In most of the Coniferæ, and in certain of the more heavily lignified dicotyledons, the secondary walls of the tracheary elements swell greatly but do not dissolve or disintegrate. Although the residues of the secondary walls may or may not be present after the action of 72% sulphuric acid, the compact remains of the so-called middle lamella persist. Such "middle lamella" residues always consist of at least three layers, *Figure 21*, and at times may be composed of five layers, *Figure 16*. Five-layered structures occur where the residues of the heavily lignified outer layers of the secondary walls remain closely attached to the residues of the cambial walls and of the intercellular substance. They may be differentiated from the three-layered residues by the structure of the bordered pits (compare (a) in *Figure 16* with *Text figure 2*). If the residues are five-layered, the pits retain their bordered appearance.

Since lignin and pectic compounds are isotropic, the anisotropy of the cambial walls suggests that the cellulose which is present originally persists during tissue differentiation and during the physiological processes of lignification. But what becomes of the polyuronides? Are they replaced by, or transformed into, lignin, or are they merely masked by lignification, which modifies their chemical solubilities, staining reactions, and other properties? Since the so-called middle lamella is intensely lignified, and since the presence of lignin may alter the reactions of the polyuronides, these questions should be attacked by a study of delignified material. It is essential, however, in delignifying wood to use solvents that do not simultaneously remove both lignin and polyuronides. For example, hot sodium sulphite macerates, and removes pectic substances from the cambium and other soft tissues. Thus, the fact that sections of wood are quickly macerated by alternate chlorinations and treatments with hot sodium sulphite does not indicate neces-

sarily that the intercellular layer is composed solely of lignin rather than of a mixture of lignin and polyuronides.

An extensive study of the delignification of wood by standard procedures indicates that delignification and maceration are not necessarily coincident reactions. When sections of various dicotyledons are given alternate treatments with chlorine water and 10% ammonium hydroxide in either aqueous or alcoholic solution at room temperature, until they no longer show traces of the Mäule reaction, *they do not macerate*, although they dissolve completely in 72% sulphuric acid. The delignified sections *may be macerated*, however, by subsequent treatments with standard solvents for polyuronides. In other words, the isotropic intercellular substance of mature wood appears to be composed of two substances, lignin and polyuronides, which may be separated by their differential solubilities.

In delignified sections of wood, the cambial walls react much as they do in freshly cut sections of the cambium. In both types of sections, they persist as a non-cellulose residue after treatment with Schweizer's reagent, *Figure 15*. Furthermore, both types of sections are completely soluble in cuprammonium hydroxide after treatment in solvents of polyuronides. In other words, the cambial walls of the mature wood appear to be composed of a mixture of lignin, cellulose and polyuronides.

If the polyuronides originally present in the cambium persist in the mature xylem, and are more or less masked by lignification, it should be possible to extract substances of a pectic nature from wood. This has been accomplished by Professor Anderson. It should be emphasized in this connection, however, that, if the polyuronides of the so-called middle lamella are of a pectic nature whereas those of the secondary wall are hemicelluloses—as appears to be the case—the yields of the former when computed as percentages of the total dry weight of the wood must of necessity be very low. This is due to the fact that the volume of the cambial walls and intercellular substance is very small in comparison with that of the thick secondary walls. In the cambium and other soft tissues, on the contrary, the intercellular substance and the cambial or primary walls form a high percentage of the total dry weight of the tissue. Therefore, the yields of pectic compounds from a given weight of such tissue is high in comparison with that of mature wood. It is evident accordingly that a transformation of pectic compounds into hemicelluloses and lignin is not essential to account for the fact that soft tissues give high percentages of pectic substances and low yields of hemicelluloses, whereas wood gives high percentages of hemicelluloses and lignin and low yields of pectic compounds.

DISCUSSION

The data recorded in preceding paragraphs indicate that the walls of the cambial initials contain cellulose and are truly anisotropic, and that these walls retain their cellulose and anisotropy during tissue differentiation. Similarly, there is considerable cumulative evidence to indicate that the polyuronides which are present in the walls of the cambial initials and constitute the bulk of the intercellular material, are carried over into the mature wood, and are not entirely replaced by, or transformed into, lignin.

Ritter's (19, 20) arguments for considering that the "middle lamella" is composed largely of "lignin" rather than of pectic compounds are the following: (1) When sections of mature wood are subjected to a standard process for isolating cellulose—i. e., alternate chlorinations and treatments with hot sodium sulphite to remove lignin—the "middle lamella" dissolves, leaving the secondary walls, which are birefringent and are soluble in 72% sulphuric acid. (2) Conversely, when sections are treated with 72% sulphuric acid, the "middle lamella" remains intact, but may be dissolved by subsequent chlorinations and treatments with hot sodium sulphite. (3) When sections are treated with standard solvents of pectic compounds, the "middle lamella" is not dissolved. (4) Ruthenium red is not specific for pectic compounds.

We have shown that delignification and maceration, produced by chlorinations and treatments with dilute alkalis, are not necessarily coincident reactions. Sections of wood may be delignified without dissolving the so-called middle lamella. Such delignified sections may be macerated by the subsequent use of standard solvents for polyuronides. Where sections of wood are macerated by repeated chlorinations and treatments in hot sodium sulphite, the truly isotropic intercellular material dissolves, but the cellulose-containing cambial walls do not. In other words, all of the middle lamella—as defined by Van Iterson, Ritter, and others—does not dissolve when sections are macerated by these standard procedures for removing lignin. Furthermore, we have found that hot sodium sulphite alone is a rapid macerating agent for the cambium and other meristems. Thus, chlorination and hot sodium sulphite remove polyuronides as well as "lignin."

We have shown that the "middle lamella" residues left after treating wood with 72% sulphuric acid always consist of at least three layers and in some cases of five layers. It should be emphasized, in addition, that lignin is not the only substance present in plant tissues that is insoluble in 72% sulphuric acid. Dadswell (8) has shown that much of the "Gerbstoffe" which fills the lumens and saturates the walls of

the xylem cells of *Eucalyptus* and of other genera remains as a residue after standard treatments with 72% sulphuric acid. Our own observations upon sections of a wide range of angiosperms and gymnosperms indicate that, in addition to various types of "Gerbstoffe," coagulated protoplasm and nuclei and the contents of certain types of vacuoles may persist after standard treatments with sulphuric acid. Although the walls of the freshly cut cambium dissolve readily in 72% sulphuric acid, they do not do so after soaking in tannic acid or if they are allowed to absorb certain phenolic substances that are contained in the vacuoles of the living cells. Such facts as these suggest that in the case of wood, the so-called lignin residues may actually consist of a varying mixture of insoluble substances.

The ruthenium red reaction was developed by Mangin (17) during his extensive investigations of the distribution of pectic substances in plant tissues. Although it is not specific for pectic substances, it is extremely useful, when employed with proper precautions, in analytical work. Our investigations of a wide range of organic compounds of known chemical composition indicate that ruthenium red in dilute solutions stains three distinct categories of substances that are of common occurrence in the cambium and its derivative tissues: (1) coagulated protoplasm and nuclei, (2) certain lipoids, and (3) polysaccharides that contain glycuronic or galacturonic acid, e.g., pectic compounds, gums, mucilages, hemicelluloses, oxycellulose, etc. In view of the fact that the first category of substances may be differentiated microscopically and that the second category are removed by preliminary treatments with lipoid solvents, an intense staining of cell walls with ruthenium red is strong presumptive evidence of the presence of polyuronides. Thus, the ruthenium red reaction is extremely useful, not only in studying the distribution of polyuronides in plant tissues, but also in chemical analyses, as a means of visually following the effects of successive steps in the extraction of such substances. We have utilized it effectively in our cooperative investigations with Professor Anderson as a means of modifying chemical techniques for the extraction of pectic compounds and hemicelluloses, and of securing larger yields of these substances from specific tissues.

Ritter's data may be interpreted as demonstrating that the so-called middle lamella is strongly lignified, but they do not provide a reliable basis for concluding that it is composed of lignin rather than of cellulose, polyuronides, and lignin. Our observations, on the contrary, tend to support the views of Schmidt and his co-workers (26, 27), who have argued that lignin occurs in close association with polyuronides.

As stated in our introduction, there is no consensus of opinion concerning the use of such terms as intercellular substance, middle lamella, primary wall, etc. Serious discrepancies in morphological, biophysical, and biochemical investigations have arisen not only owing to differences in definition, but also as a result of inconsistencies in applying specific terms to different tissues and even to the same tissue when different techniques are employed. It is essential to clarify the situation, if possible.

That Dippel and others are not consistent in their use of the terms, *intercellular substance*, *middle lamella*, and *primary wall*, is indicated by a careful study of their texts and particularly of their illustrations of different tissues, *Table 1*. Thus, in dealing with the secondary xylem, Dippel (10) obviously uses the term *middle lamella* in referring to a five-layered structure which consists of two cambial walls, two layers of secondary thickening, and a layer of intercellular material, *Text figure 1*. His isotropic substance—i. e., Van Iterson's (33) "original or true middle lamella" and the middle lamella or primary wall of various other

TABLE I

COMPARATIVE TERMINOLOGIES

Proposed Terminology
for

Soft Tissues	SOFT OR WOODY TISSUES (Text figures 1 and 2)	Woody Tissues
	(a)	
Intercellular Substance (Dippel) =	MIDDLE LAMELLA or INTERCELLULAR SUBSTANCE	b+a+b: Intercellular Substance (Dippel); Middle Lamella (Van Iterson and others); Primary Wall (Various botanists)
	(b)	
Primary Wall (Dippel) =	CAMBIAL or PRIMARY WALL	
	(c)	
	OUTER LAYER OF SECONDARY WALL	= Primary Wall (Dippel and others)
	(d)	
	CENTRAL LAYER OF SECONDARY WALL	= Secondary Wall (Dippel and others)
	(e)	
	INNER LAYER OF SECONDARY WALL	= Tertiary Wall (Dippel and others)

c+b+a+b+c = Middle Lamella of Dippel and Intercellular Substance of earlier botanists

writers—actually consists of two feebly anisotropic walls and a layer of truly isotropic intercellular material. His primary wall is the strongly isotropic first-formed layer of secondary thickening. On the contrary, in dealing with the unlignified parenchyma of other tissues, Dippel frequently uses the term *primary wall* in referring to layers that are homologues of the cambial walls, and the term *intercellular substance* in designating the truly isotropic intercellular material. It should be emphasized, in this connection, that many of the most serious discrepancies are due, on the one hand, to confounding the cambial walls with the intercellular material, and, on the other hand, to confusing them with the narrow outer layer of the secondary wall.

The question arises, accordingly, as to what changes are advisable in the definition and use of such terms as *middle lamella, intercellular substance,* and *primary wall.* Are they so firmly established in the literature that they should be retained and redefined, or has their varied use led to so much confusion that they should be replaced by new terms?

Our own conclusions, based upon a detailed study of the cambium and its derivatives and upon preliminary investigations of other meristems and their derivatives, are (1) that the term *primary wall* should not be applied to the first-formed layer of secondary thickening but should be used solely in designating the cambial wall and its homologues in other tissues, and (2) that the term *middle lamella* should be used synonymously with *intercellular substance* in referring to the truly isotropic layer of intercellular material. If some term of convenience is required in referring to those complexes of lignified layers which appear more or less homogeneous under certain specific conditions, Van Iterson's term, *compound middle lamella* is available. It should be clearly recognized, in this connection, however, that the compound middle lamella will be five-layered or three-layered, depending upon the specific techniques used in examining the tissue.

Our reasons for advocating these changes in terminology are the following: There are two distinct and fundamentally different categories of cell walls. Meristematic elements and such of their derivatives as retain a potentiality for growth and enlargement have walls which are characterized by their capacity for growth and extension and for undergoing reversible changes, e. g., in thickness. On the contrary, tissue cells which undergo irreversible changes and thus lose their potentiality for growth and enlargement may form a supplementary or *secondary wall* which tends to be more or less conspicuously laminated.[1] The

[1]This differentiation of primary and secondary walls is similar to that used by Balls (6) in his study of the structure of the cotton hair.

term *primary* wall has been used in referring to the walls of meristematic elements, to the walls of their enlarging derivatives, and to the first-formed layer of true secondary thickening in lignified tissues. To continue to apply the term *primary wall* to two entirely different structures must inevitably perpetuate the existing confusion. Therefore, in view of the fact that the cambial wall—and its homologues in other tissues—is a discrete morphological structure which maintains its identity under all conditions of growth and development, it seems advisable to designate it as the *primary wall*. Any terminology which attempts to differentiate successively formed layers of secondary thickening as primary, secondary, and tertiary walls breaks down completely when applied to all types of cells, i. e., to vessel, fibers, sclerenchyma, etc.

The term *middle lamella,* which was used originally as a substitute for *intercellular substance,* has been employed in the case of lignified tissues in referring to five-layered or three-layered structures and in the case of soft unlignified tissues in designating a layer of truly isotropic material. In view of the fact that there has been an increasing tendency to apply the term to a supposedly isotropic layer in lignified tissues, it seems desirable to restrict the term to the truly isotropic *intercellular substance* which separates the primary walls of adjoining cells.

The objection may be raised that the partition membrane is secreted between the halves of the split cell plate, that it originates as a single unit which has a "primary cleavage plane," and therefore that the two adjacent cambial walls and the subsequently formed intercellular material should be designated as the middle lamella or primary wall. The conception of a cell plate which originates from central thickening of spindle fibers and divides to form two protoplasmic membranes, and of a partition wall which is secreted between the halves of the split cell plate and possesses a predetermined plane of cleavage, rests upon entirely inadequate cytological evidence. It has been severely criticized in recent years by Robyns (21) and others and is questioned by most of those who have worked with living cells and are familiar with the physico-chemical properties of living protoplasm. The colloidal properties of the spindle, the cell plate, and first-formed partition membrane are such that they tend to become more or less profoundly modified during fixation and in injured or plasmolyzed living cells. There is no reliable evidence at present to refute Mangin's suggestion that pectic substances are secreted between the newly formed protoplasmic membranes and that mixtures of cellulose and pectic substances are not formed until subsequently.

In the case of cambial initials and of many other cells, a fraction only of the cambial wall originates during cytokinesis. A large proportion of the wall is formed by the growth and extension of its existing surfaces.

Therefore, in view of the fact that each cambial wall is a discrete morphological structure which maintains its identity under all conditions of growth and development, we do not believe that terminology should be governed solely by phenomena which occur during cytokinesis.

SUMMARY AND CONCLUSIONS

1. A detailed study of the cambium indicates that each initial is enclosed within a wall of its own which is separated from the walls of adjoining initials by more or less intercellular material.

2. The cambial wall is composed largely of cellulose and polyuronides, and is truly anisotropic. It is characterized by its capacity for growth and extension and for undergoing reversible changes in thickness. It is also characterized by possessing plasmodesmata which may be uniformly distributed or aggregated in more or less conspicuous primary pit-fields.

3. The amorphous intercellular material, on the contrary, is composed largely, if not entirely, of polyuronides and is truly isotropic. It is characterized by its plasticity which facilitates those movements and adjustments of cells which are such typical features of the actively growing cambium.

4. In other words, the wall of the cambial initial is a discrete morphological structure which maintains its identity under all conditions of growth and development, whereas the intercellular material is passively molded into various forms and possesses few of the attributes of a true membrane.

5. In the case of those derivatives of the cambium which retain their capacity for growth and enlargement and for undergoing reversible changes, the cambial walls are but slightly modified during tissue differentiation, and no supplementary walls are formed.

6. On the contrary, in the case of tissue cells which undergo irreversible changes and form layers of true secondary thickening, the cambial walls and the intercellular layer become thinner and considerably modified in form during the process of cell enlargement. Furthermore, their optical properties, chemical solubilities, and staining reactions are altered or masked by intense lignification.

7. It is possible to demonstrate, however, that the cambial walls retain their anisotropy during and after tissue differentiation, and, by accurately controlled delignification, to unmask the original chemical solubilities and staining reactions of both the cambial walls and the intercellular material. There is, in fact, much cumulative evidence to indicate that the original cellulose and polyuronides are not completely replaced by or transformed into lignin during tissue differentiation.

8. Thus, the putative "isotropic middle lamella" of the mature xylem is not a homogeneous layer, but consists of two lignified anisotropic cambial walls and an intervening, truly isotropic layer of lignified material.

9. Residues of the so-called middle lamella, obtained by the action of 72% sulphuric acid on mature wood, always consists of at least three layers, i. e. the residues of two cambial walls and of the intercellular material.

10. In macerations produced by repeated chlorinations and treatments with hot sodium sulphite, which dissolves both lignin and pectic compounds, a portion only of the so-called middle lamella dissolves, i. e. the truly isotropic intercellular material. The cellulose-containing cambial walls persist and adhere to the layers of secondary thickening.

11. Delignification of the so-called middle lamella and maceration are not necessarily coincident reactions. By carefully controlled chlorinations and treatments with 10% ammonium hydroxide at room temperatures, sections of wood may be delignified without dissolving the so-called middle lamella. Such delignified sections may be macerated, however, by subsequent treatments with standard solvents of pectic substances. In other words, the isotropic intercellular substance of mature wood appears to be composed of two substances, lignin and pectic compounds, which may be separated by their differential solubilities.

12. Serious discrepancies in the use of such terms as *intercellular layer*, *middle lamella*, and *primary wall* are due not only to differences in the definition of these terms, but also to inconsistencies in applying them to different tissues, and even to the same tissue when different techniques are employed.

13. As a result of our detailed study of the cambium and its derivatives and of our preliminary investigations of other meristems and their derivatives, we suggest (1) that if the term *middle lamella* is to be retained, it should be used synonymously with *intercellular substance* in referring to the truly isotropic layer of intercellular material and (2) that the term *primary wall* should no longer be applied to the first-formed layer of secondary thickening, but should be used solely in designating the cambial wall and its homologues in other tissues.

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DESCRIPTION OF PLATES

Plate 110

Photomicrographs made with polarized light and crossed nicols. Figs. 3-7 from sections 5 μ in thickness.

Fig. 1. *Pinus Strobus.* Transverse section of the actively growing cambium and its differentiating and fully differentiated derivatives, showing anisotropy of the cambial walls. × 265.

Fig. 2. *Fraxinus americana.* Tangential longitudinal section of the cambium, showing anisotropy of the walls of both ray initials and fusiform initials. × 210.

Fig. 3. *Pinus Strobus.* Tangential longitudinal section of the cambium, showing anisotropic walls of two adjacent fusiform initials and the isotropic intercellular material. The thinner areas of the walls are the so-called primary pit-fields. × 1510.

Fig. 4. *Fraxinus americana.* Tangential longitudinal section of the cambium, showing the anisotropic walls of two adjacent fusiform initials and beaded appearance due to closely approximated primary pit-fields. × 1510.

Fig. 5. *Trochodendron aralioides.* Transverse section of the latewood, showing one entire tracheid and portions of seven adjoining ones. The thick secondary walls are composed of three layers: a narrow, brilliant, outer layer, a brilliant, narrow, inner layer, and a wide intervening dark layer. The brilliant outer layers of adjoining secondary walls are separated by a narrow dark layer, i. e., the so-called middle lamella, which actually consists of two feebly anisotropic cambial walls and a truly isotropic layer of intercellular material (Compare *Text fig. 1*). × 1415.

Fig. 6. *Trochodendron aralioides.* Transverse section of the earlywood, showing one entire tracheid and portions of seven others. Details of structure as in *Fig. 5*, except for the difference in thickness of the central layer of the secondary wall. × 1415.

Fig. 7. *Myodocarpus simplicifolius.* Transverse section of the xylem, showing one entire fiber-tracheid and portions of six adjoining ones. The feebly anisotropic cambial walls are visible between the adjacent outer brilliant layers of the secondary walls. × 1510.

PLATE 111

Fig. 8. *Sequoia sempervirens.* Transverse section of the xylem, unstained and photographed in white light. The inner and outer layers of the secondary wall are more refractive than the wide central layer. The outer layers of adjacent secondary walls blend with the intensely lignified cambial walls and intercellular substance, forming an apparently homogeneous middle lamella which actually consists of five layers. Section of bordered pit at the right. ×1320.

Fig. 9. *The same.* Photographed in polarized light with crossed nicols. In a section of this thickness, 15 μ, the isotropic intercellular substance and feebly anisotropic cambial walls are completely fogged or obscured by the brilliant outer layers of the secondary walls. (Compare *Fig. 5* for section 5 μ in thickness.) × 1320.

Fig. 10. *Fraxinus americana.* Tangential longitudinal section of the phloem, showing but slightly modified cambial walls. Compare *Fig. 11.*) × 800.

Fig. 11. *Fraxinus americana.* Tangential longitudinal section of the cambium, showing walls of ray initials and fusiform initials. × 800.

Fig. 12. *Fraxinus americana.* Tangential longitudinal section of the xylem after standard treatment with 72% sulphuric acid, showing residue of cambial walls which have not thinned down excessively during tissue differentiation. (Compare *Fig. 11.*) × 800.

Fig. 13. *Fraxinus mandshurica.* Tangential longitudinal section of the xylem, showing thick cambial walls between the secondary walls of parenchymatous elements. (Compare *Figs. 11* and *12.*) × 800.

PLATE 112

Fig. 14. *Betula papyrifera.* Transverse section of the xylem after treatment with 72% sulphuric acid. The secondary walls of the fibers have dissolved, whereas the more intensely lignified secondary walls of the vessels have not. × 180.

Fig. 15. *Taxodium distichum.* Transverse section of the xylem after five successive treatments with chlorine water and 10% ammonium hydroxide and extraction with Schweizer's reagent. The intercellular substance and secondary walls have dissolved, leaving the cambial walls only. × 875.

Fig. 16. *Pinus radiata.* Transverse section of the xylem after standard treatment with 72% sulphuric acid, showing five-layered "middle lamella" residue. The five-layered character of the residue may be accurately determined by the structure of the bordered pit at (a). × 945.

Fig. 17. *Sequoia sempervirens.* Tangential longitudinal section of the xylem, showing bordered pit in sectional view. The torus consists of two thickened areas of the cambial walls and an intervening layer of intercellular material. (Compare *Text fig. 2.*) × 2740.

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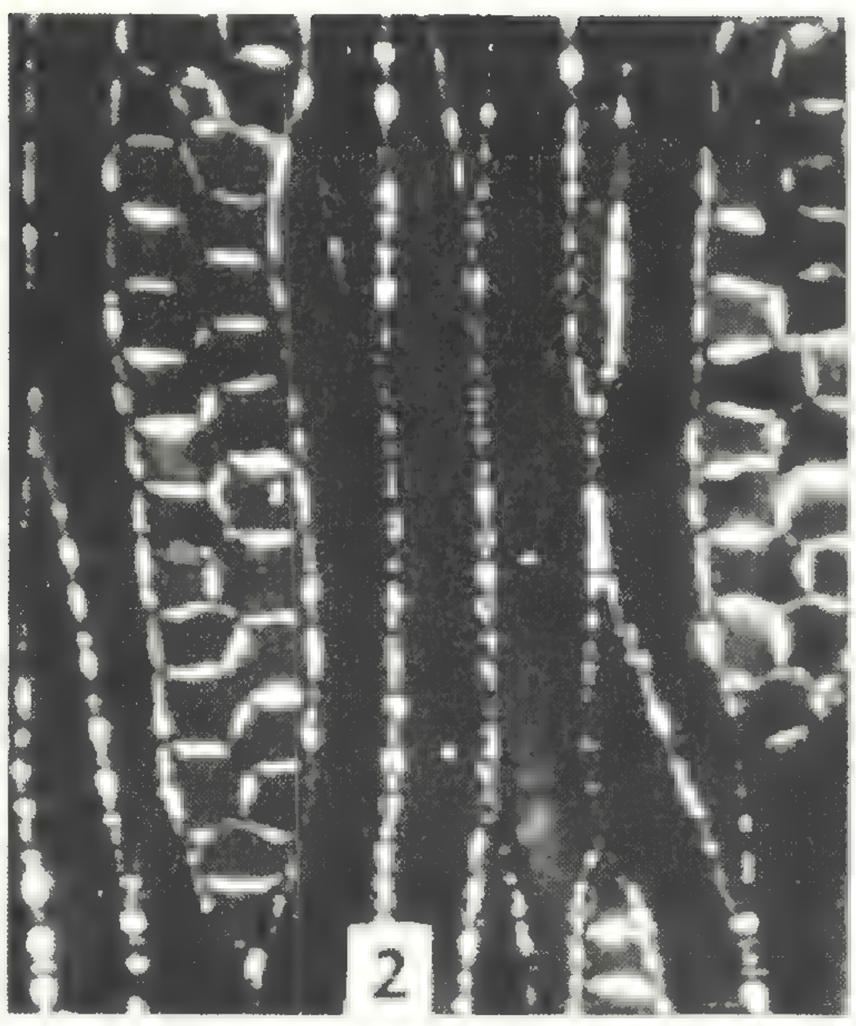
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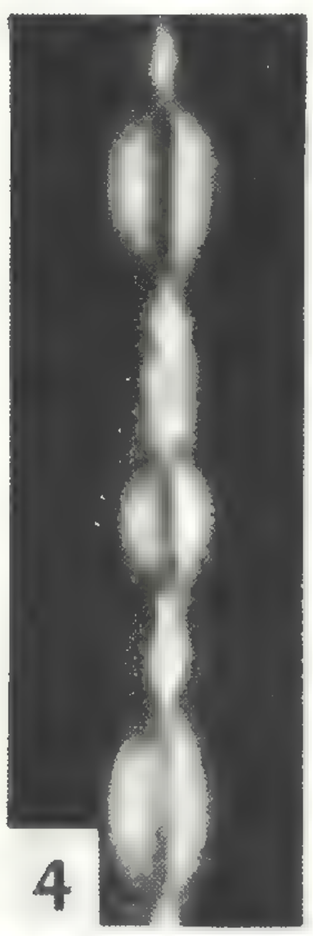
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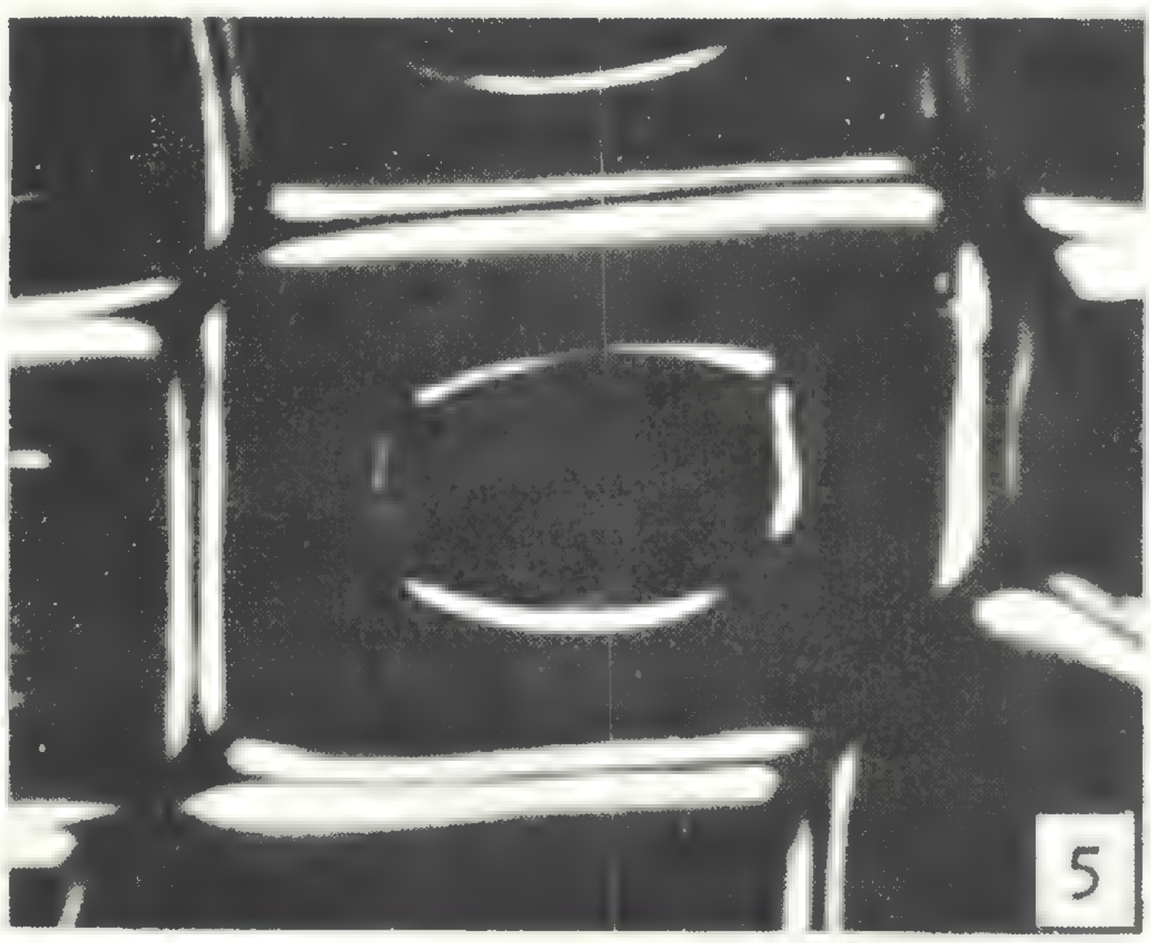
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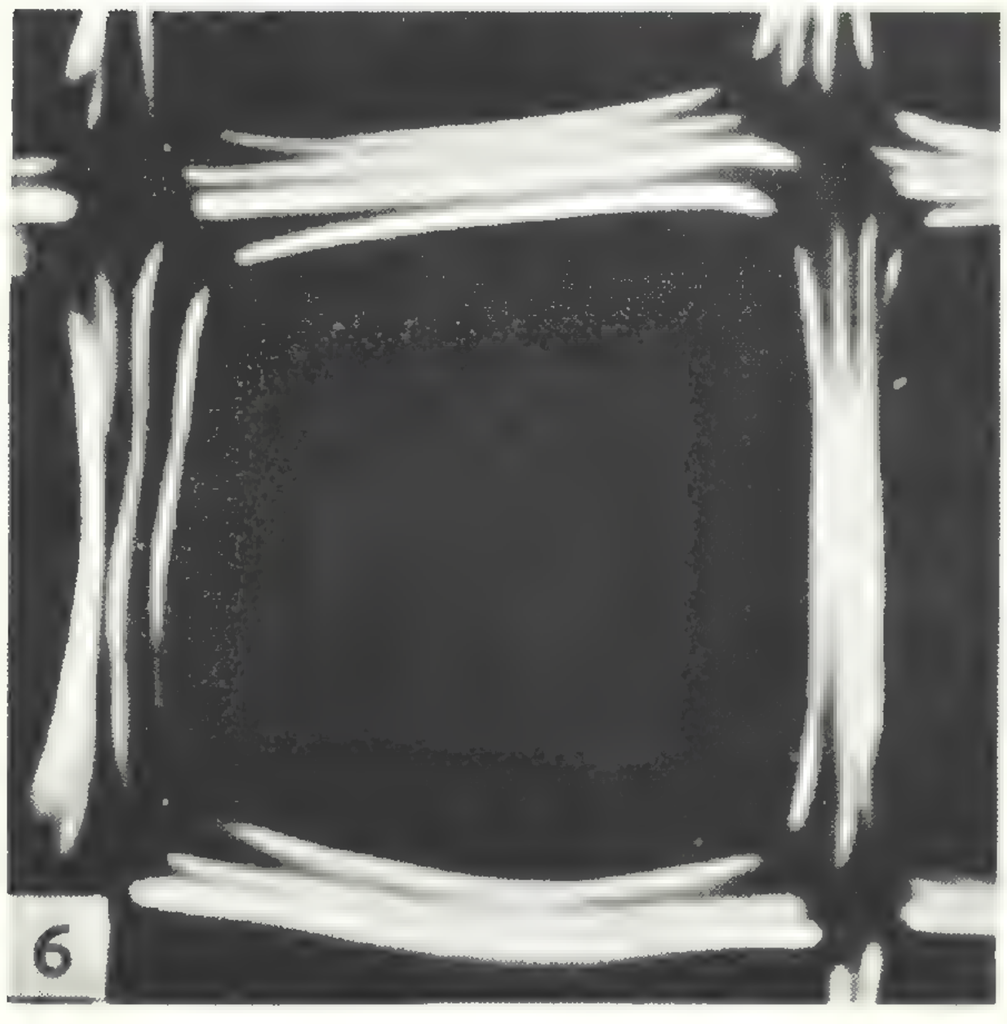
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7

THE SO-CALLED MIDDLE LAMELLA

THE HELIOTYPE CORP. BOSTON

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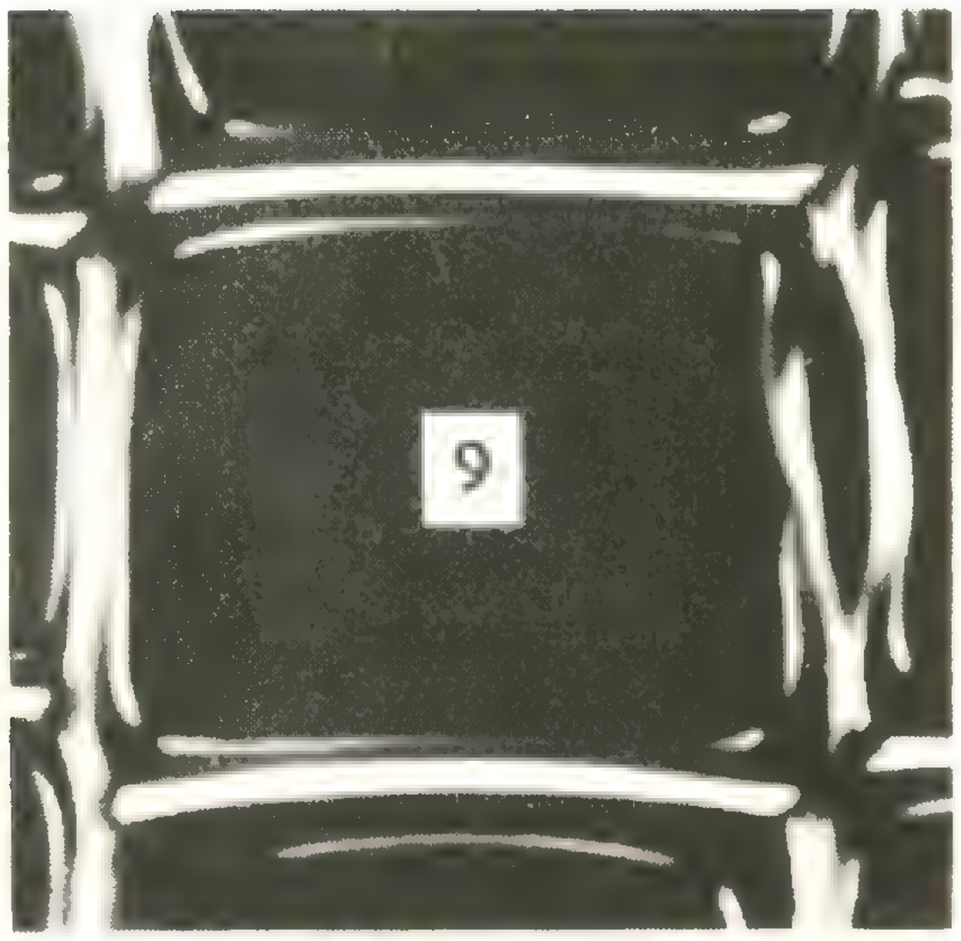
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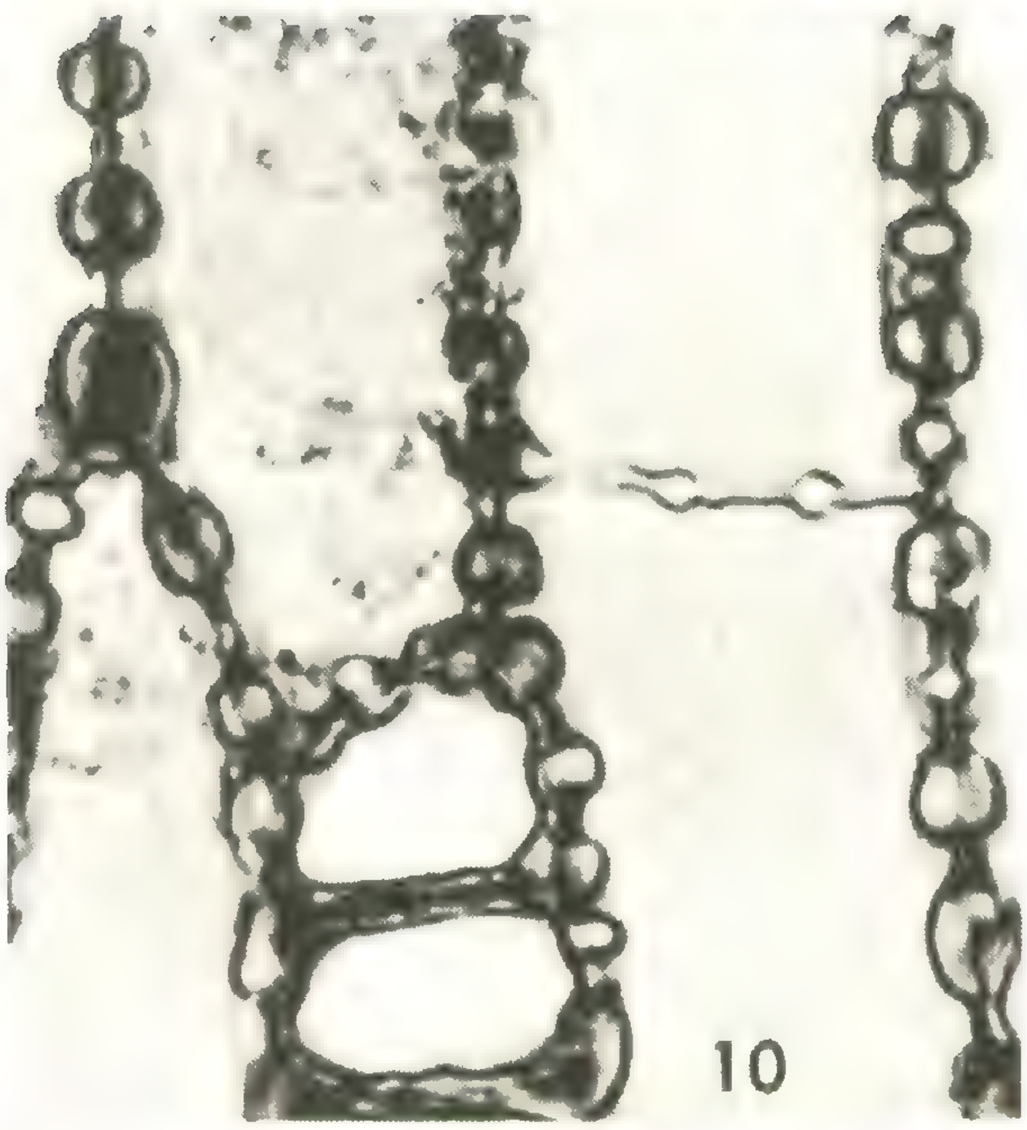
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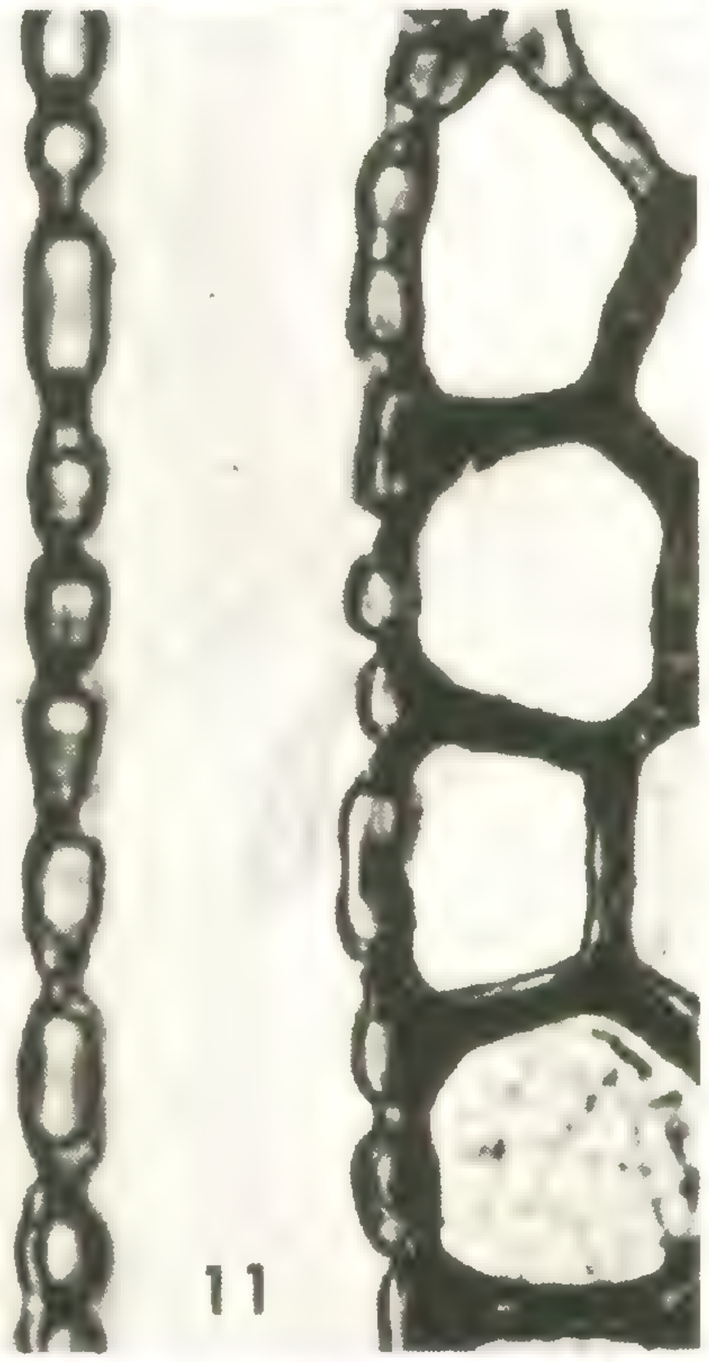
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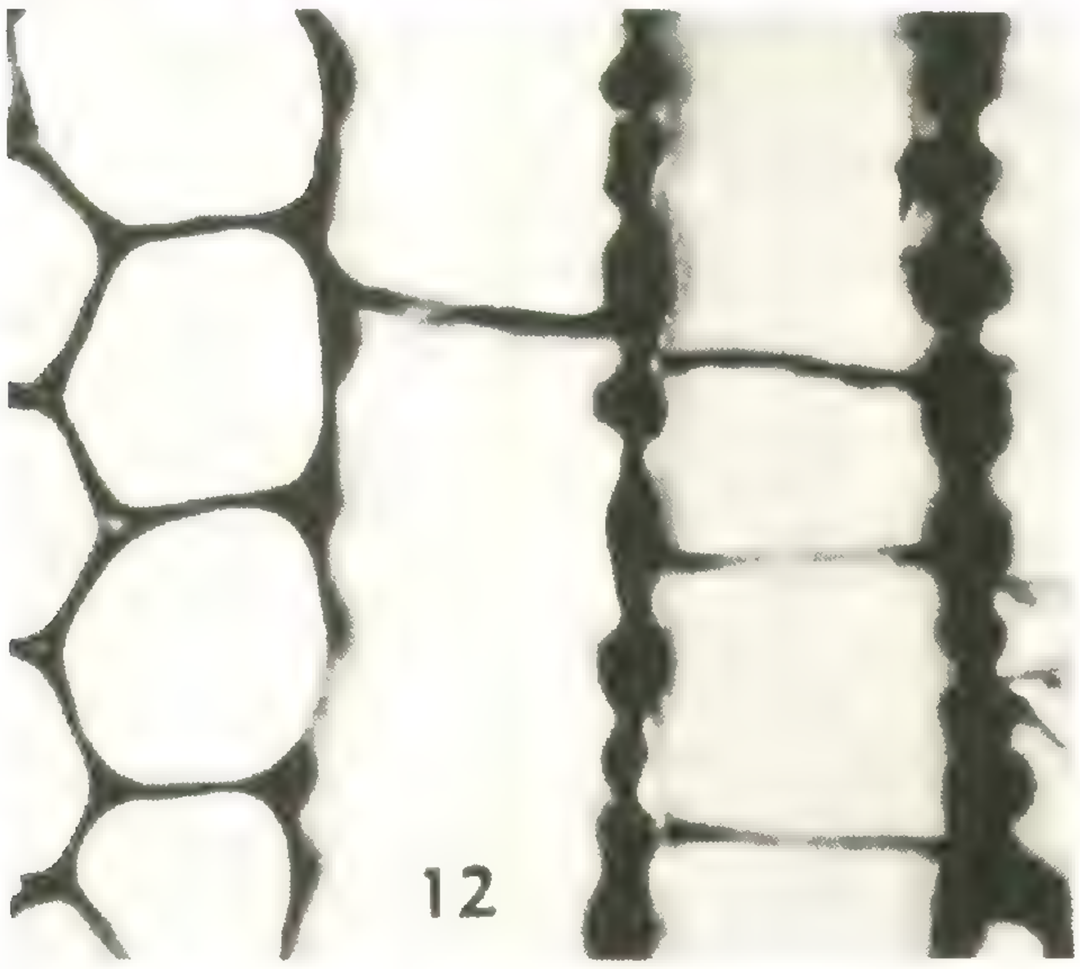
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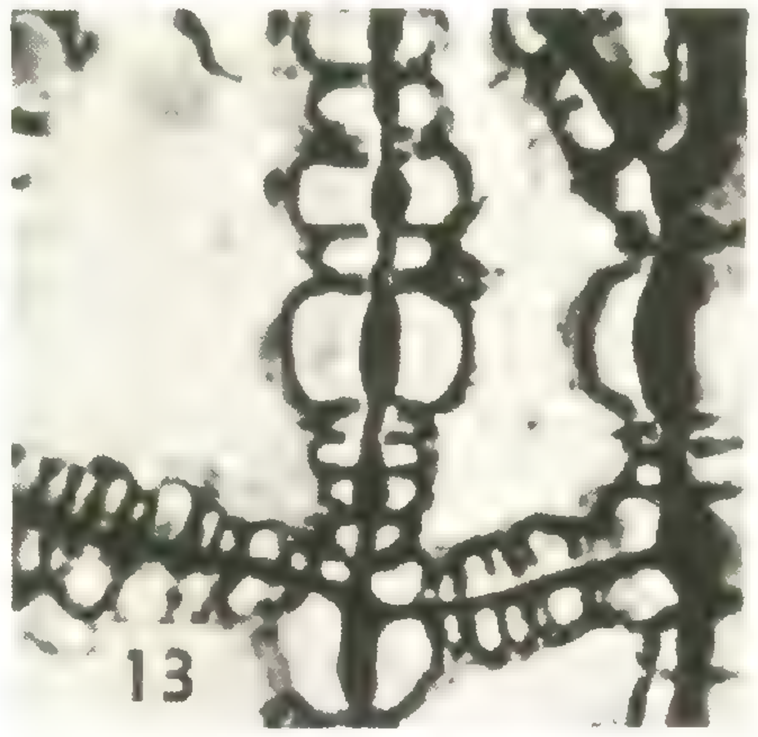
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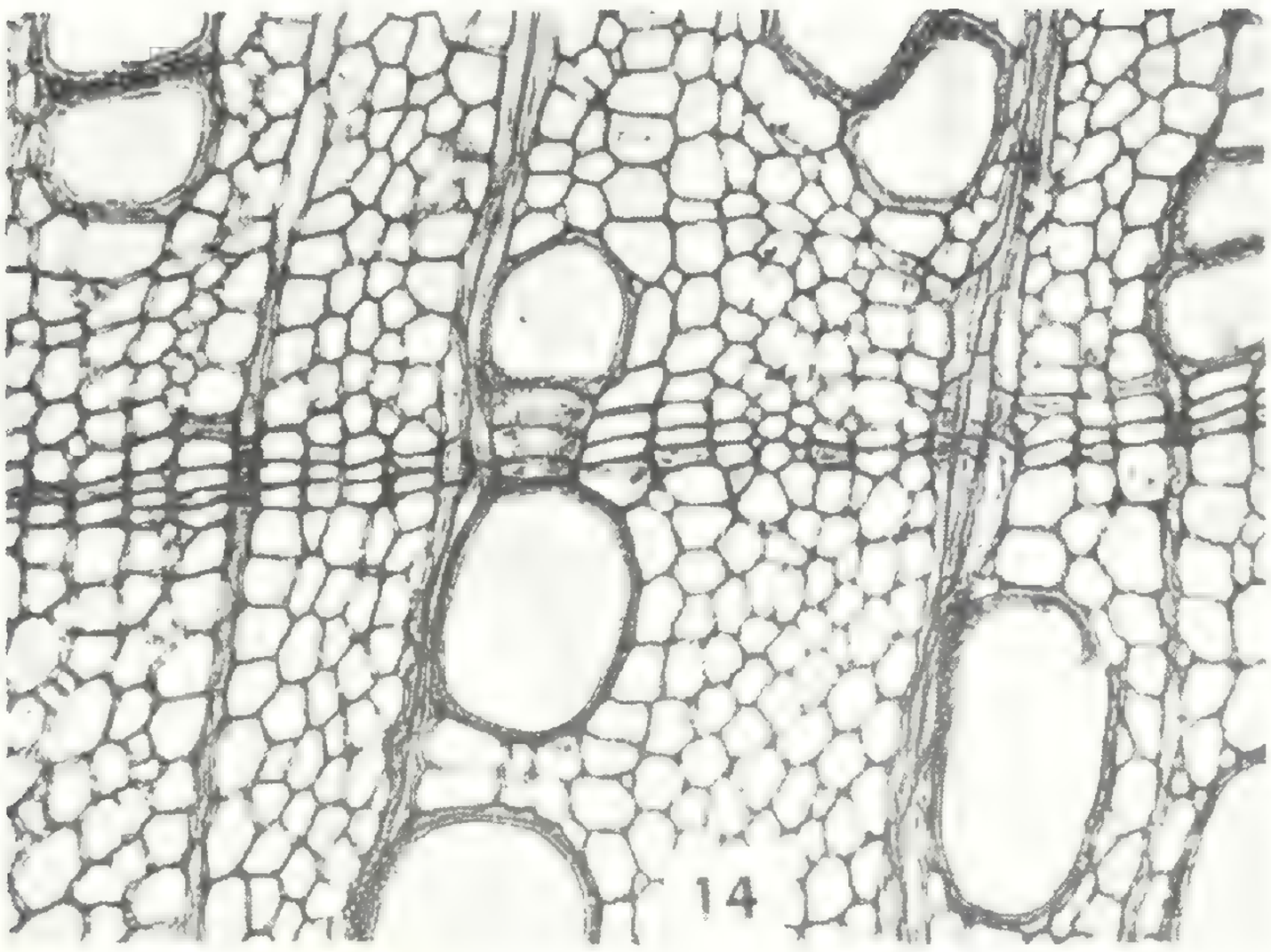
THE SO-CALLED MIDDLE LAMELLA

THE HELIOTYPE CORP. BOSTON



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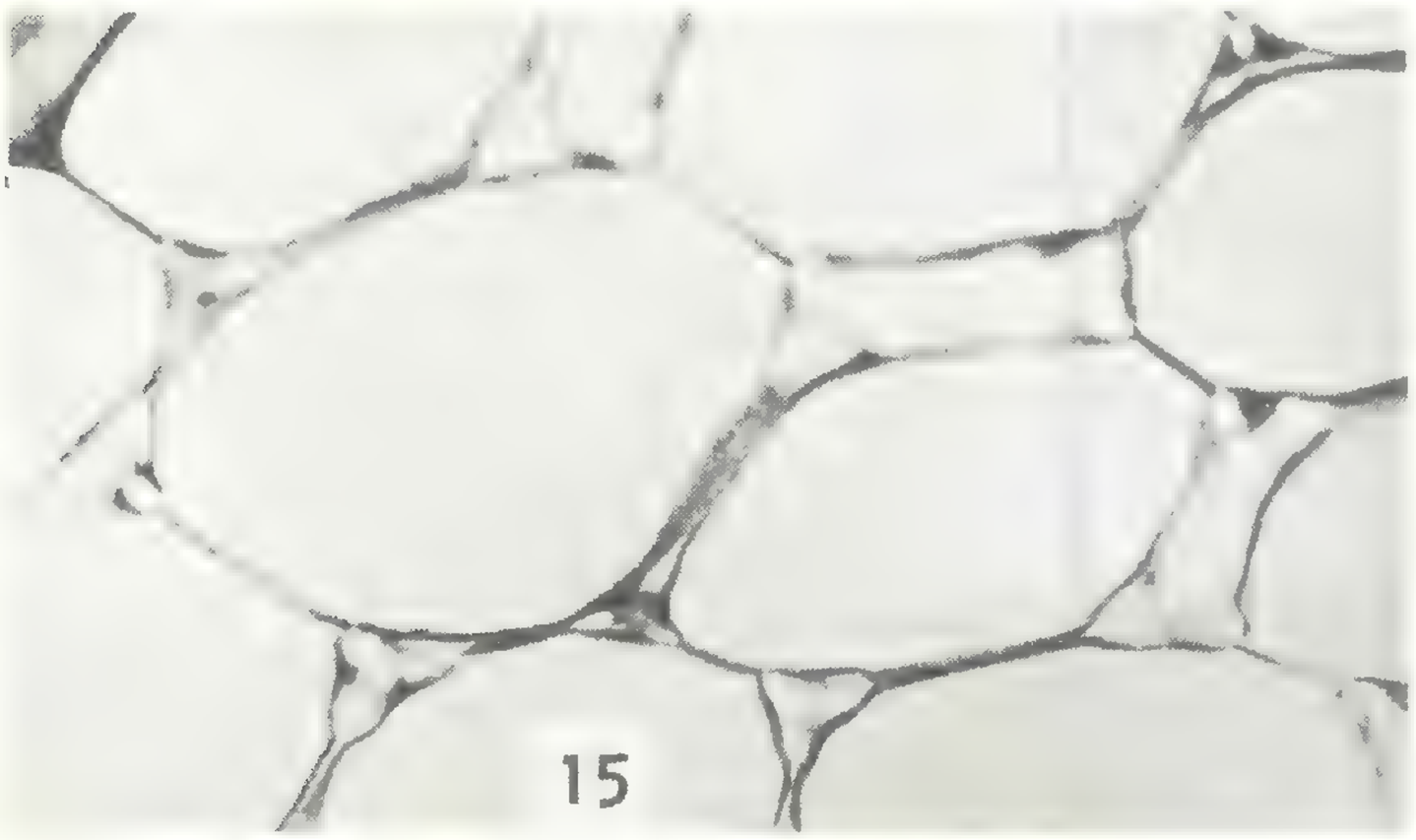

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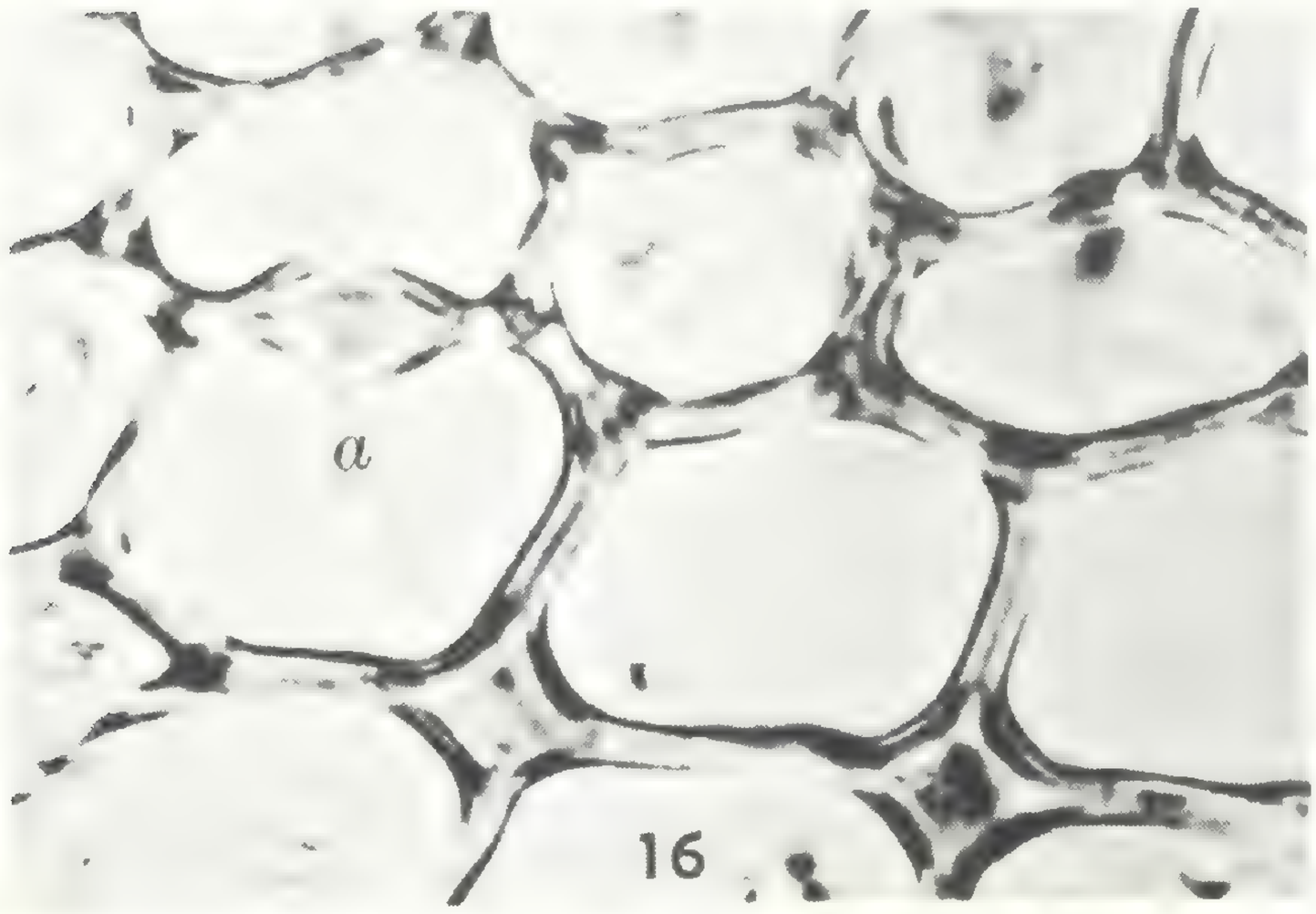

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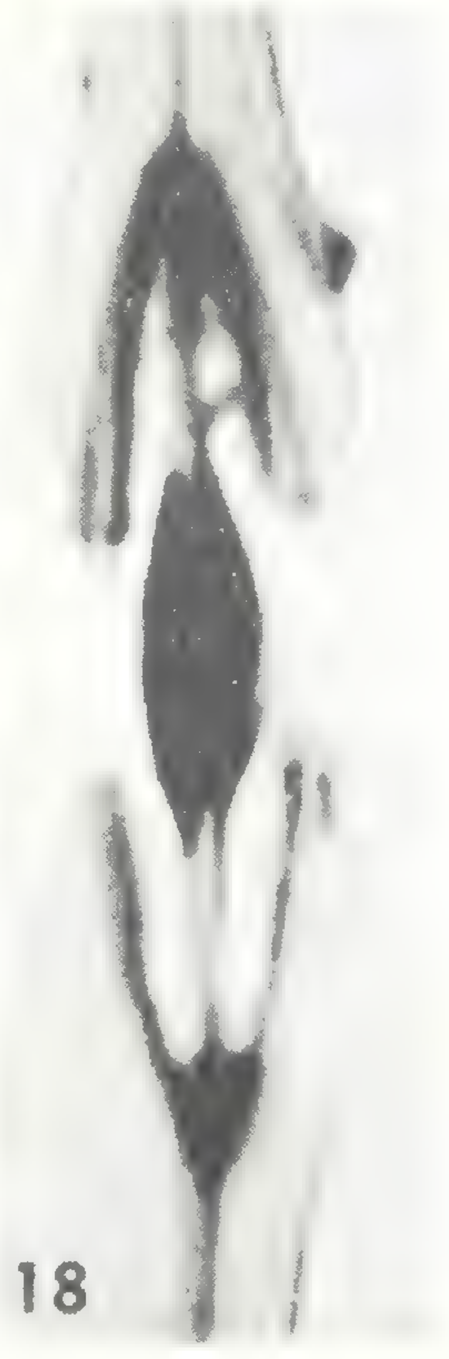

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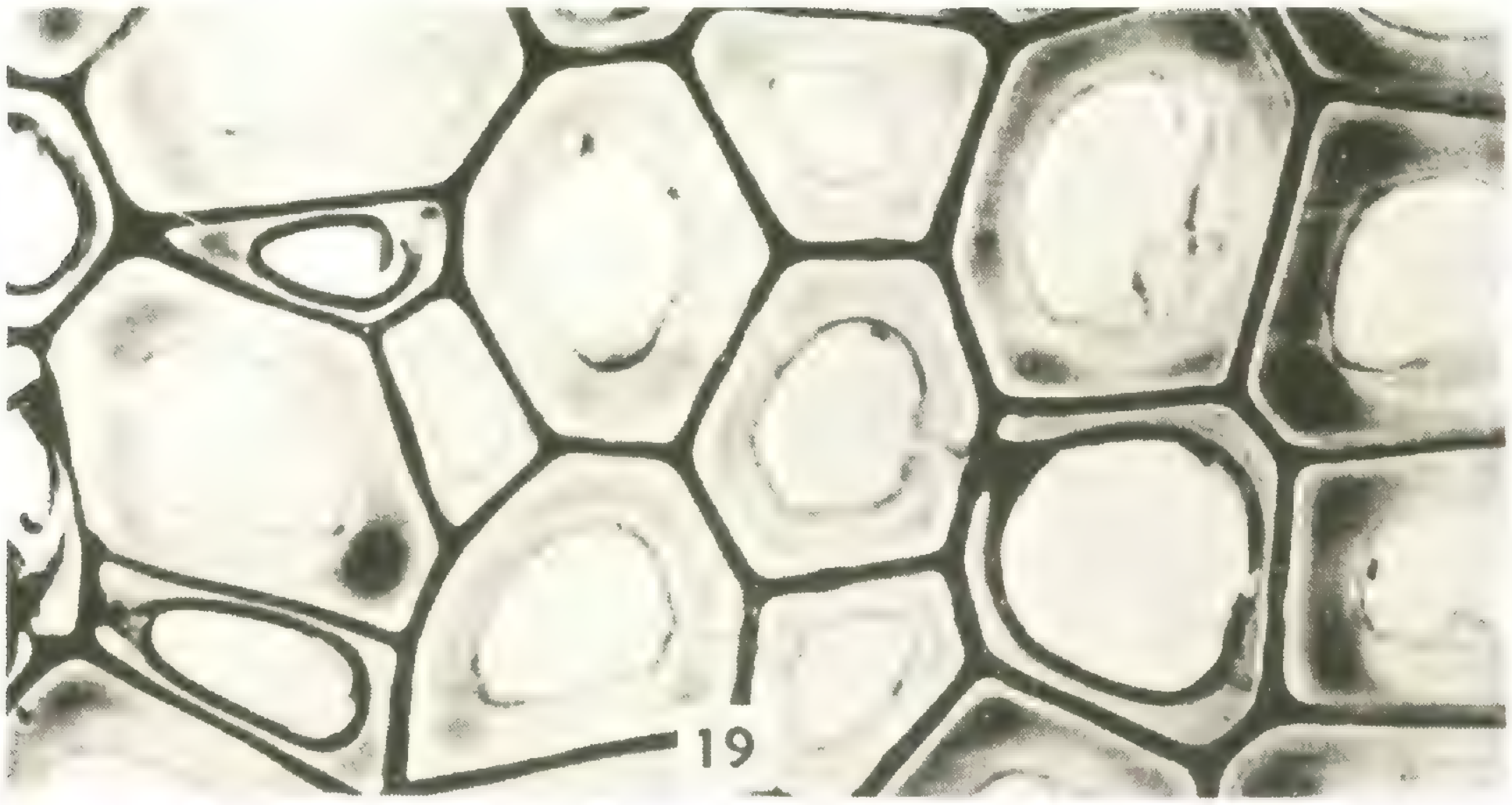
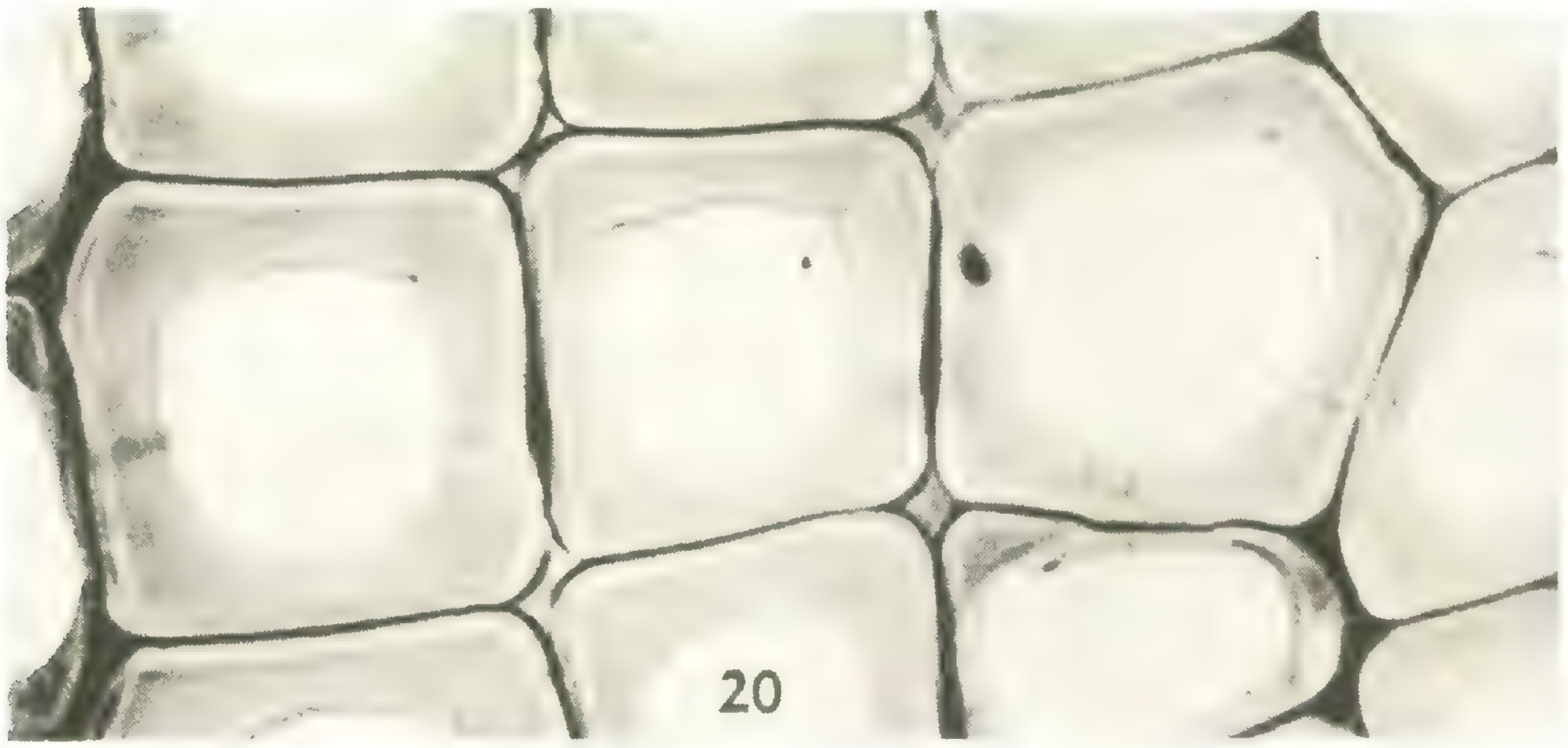
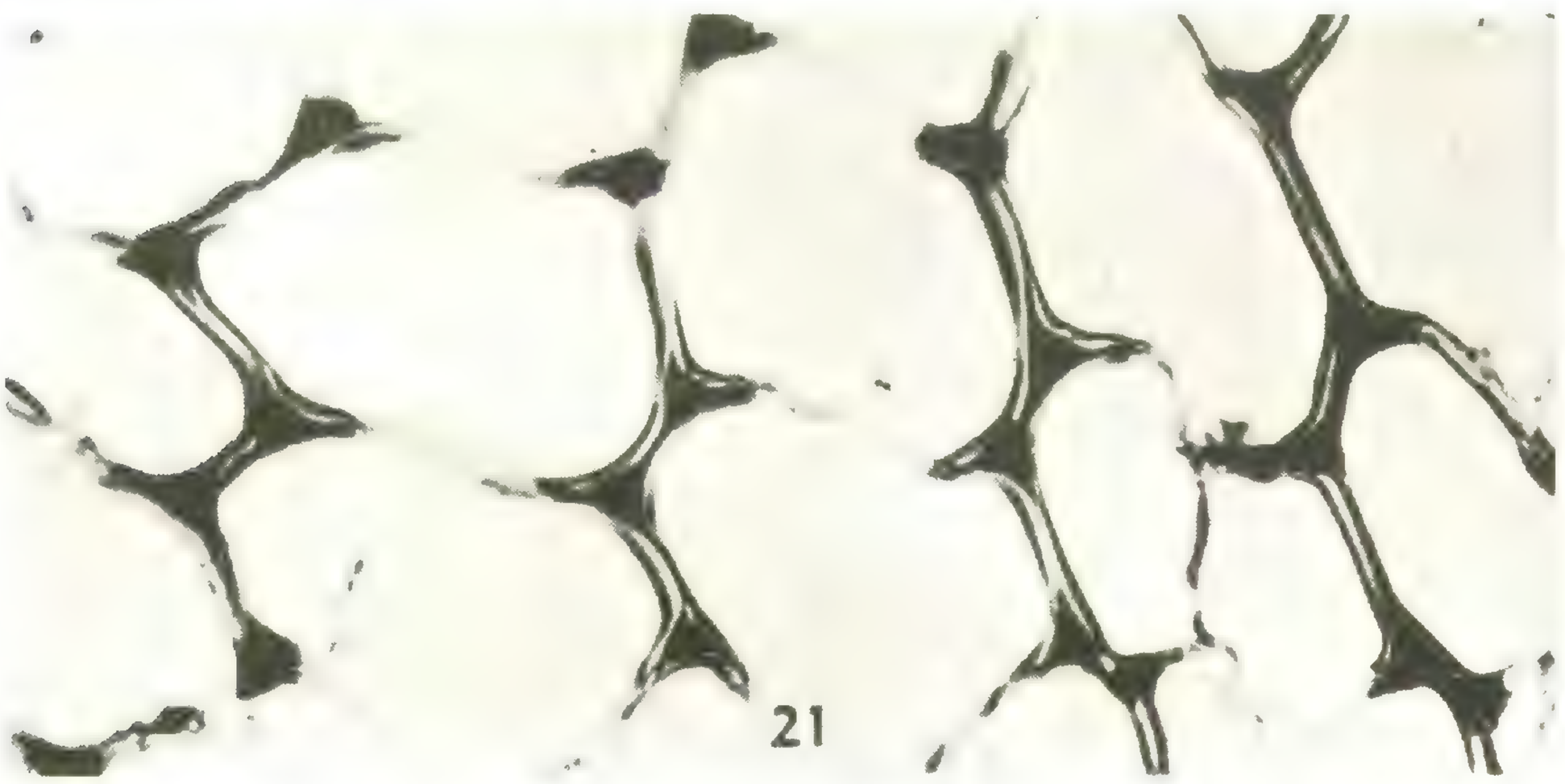
THE SO-CALLED MIDDLE LAMELLA

THE HELIOTYPE CORP. BOSTON







THE SO-CALLED MIDDLE LAMELLA

THE HELIOTYPE CORP. BOSTON

Fig. 18. *Sequoia sempervirens.* Tangential longitudinal section of the xylem, showing bordered pit in sectional view. The unlignified intercellular material of the pit-membrane has dissolved, leaving the two cambial walls intact. (Compare *Text fig. 2.*) × 2740.

PLATE 113

Fig. 19. *Trochodendron aralioides.* Transverse section of the xylem, stained with Haidenhain's hæmatoxylin and safranin, and showing deeply stained "middle lamella" which consists of two cambial walls and a layer of intercellular material. × 1130.

Fig. 20. *Trochodendron aralioides.* Transverse section of the xylem after repeated extractions with solvents of polyuronides and after staining with ruthenium red. The cambial walls are deeply stained, whereas the secondary walls and the intercellular substance are not. × 1130.

Fig. 21. *Trochodendron aralioides.* Transverse section of the xylem after standard treatment with 72% sulphuric acid and staining with ruthenium red, showing the three-layered residue of the "middle lamella." × 1130.

ARNOLD ARBORETUM, HARVARD UNIVERSITY AND
CARNEGIE INSTITUTION OF WASHINGTON.

A VERIFICATION OF THE OCCURRENCE OF YUCCA WHIPPLEI IN ARIZONA

SUSAN D. MCKELVEY

With plates 114-117

ON APRIL 3, 1858, Professor Newberry, accompanying Lieutenant Joseph C. Ives on his expedition to ascertain the navigability of the Colorado River, collected at the mouth of Diamond Creek, Mohave Co., Arizona, leaves of a *Yucca* which Dr. Torrey in 1860 determined as identical with the species which, discovered by Mr. Arthur Schott near San Pasqual in southern California, he had in 1859 named *Yucca Whipplei*. Except for the Newberry collection, unverified hitherto, the species is known only from California. Doctor Trelease in 1902 expressed doubt as to the correctness of the early record because "the locality is so far from the known range . . ."

Since the Boulder Dam project threatens to flood the Diamond Creek region it was felt important to attempt to verify the Arizona record. On May 5, 1932, with O. E. Hamilton, chauffeur-photographer, and two Indians from the Hualapai Reservation, Charles McGee and his father, the author made a trip to the mouth of Diamond Creek. Starting from Peach Spring a considerable distance was travelled by motor truck, the car following the course of a dry stream and demonstrating considerable agility in climbing boulders; the last part of the trip was made on horseback.

The creek or river received its name according to the Indians from Diamond Peak which is situated at its mouth and which in form is distinctly suggestive of the cut gem; Mr. Charles A. Coolidge of Boston, who, in 1887, with Mr. F. L. Olmsted and Professor Agassiz visited the region, says that the name is derived from the presence of small diamonds in the rock.

Diamond Creek which flows in a general northwesterly direction joins, near its mouth, the canyon through which we had descended, and empties into the southern side of the Colorado below the western end of the Grand Canyon; the elevation at this point is approximately 1500 feet but steep sides lead upward from the canyons to mesas 4000-5000 feet higher.

No plants of the desired *Yucca* were seen until within a short distance of the Colorado but then one was discovered several hundred feet

up the western slope of Diamond Creek, from a distance, in color especially, easily to be mistaken for a plant of *Dasylirion Wheeleri* though in form more symmetrical. Eventually a possible ten plants were located, most overhanging the Colorado, but none unfortunately in flower or in fruit. When the Indians understood what plant was sought they expressed familiarity with it and said that the heart was sweet and excellent eating when buried and roasted under hot coals. They also said that it was to be found considerably further to the west, always along the Colorado, but that this region was accessible only on foot or horseback and three days in from Peach Spring.

The leaves on the plants examined appeared to be unusually long for the species, most about 3 feet in length; the blade tapered from union with base to apex, was more or less four-sided, below distinctly keeled, above marked by a narrow central rib, the surface finely striate but not "watered" as is that on many of the California specimens, in color a pale sage-green, the margins pale yellow, horny, entire and sharp or somewhat finely denticulate, the spine acicular, the tip a dark maroon; the plants were 3 - 4 feet broad, solitary and widely separated.

Still desirous of finding flowers, fruit, or preferably both, and aided by the work of the Civilian Conservation Corps which a month or so before had opened up a crude road to the Colorado at a considerable distance to the west of Diamond Creek, a second trip in search of the plant was made on April 29, 1934. Starting a little east of Valentine the road wound circuitously northwestward over the mesas for about 60 miles, crossing lands of the Public Domain and of the Hualapai Reservation until it arrived at New Water Point; from this promontory one looks across and west to the Lower Granite Gorge of the Colorado and east, across Quartermaster Canyon, towards the west end of the Grand Canyon.

No *Yucca Whipplei* had been seen to the rim's edge but any discouragement felt was dissipated as one descended into the gorge for it was noted at once, again not in flower but with plentiful old and characteristic fruit. Despite exceedingly strong wind photographs were obtained as well as specimens, these now in the Herbarium of the Arnold Arboretum.

As at Diamond Creek the plants were solitary and appeared to die after fruiting; none were caespitose; they grew at a considerable distance from each other and not in great numbers. For the most part the leaves were shorter. One old fruit stalk, here illustrated, was 9 feet tall, the scape 3 feet in length, stout below, 14 inches in circumference just above the swollen base, and tapered upward to the tip; the inflorescence proper

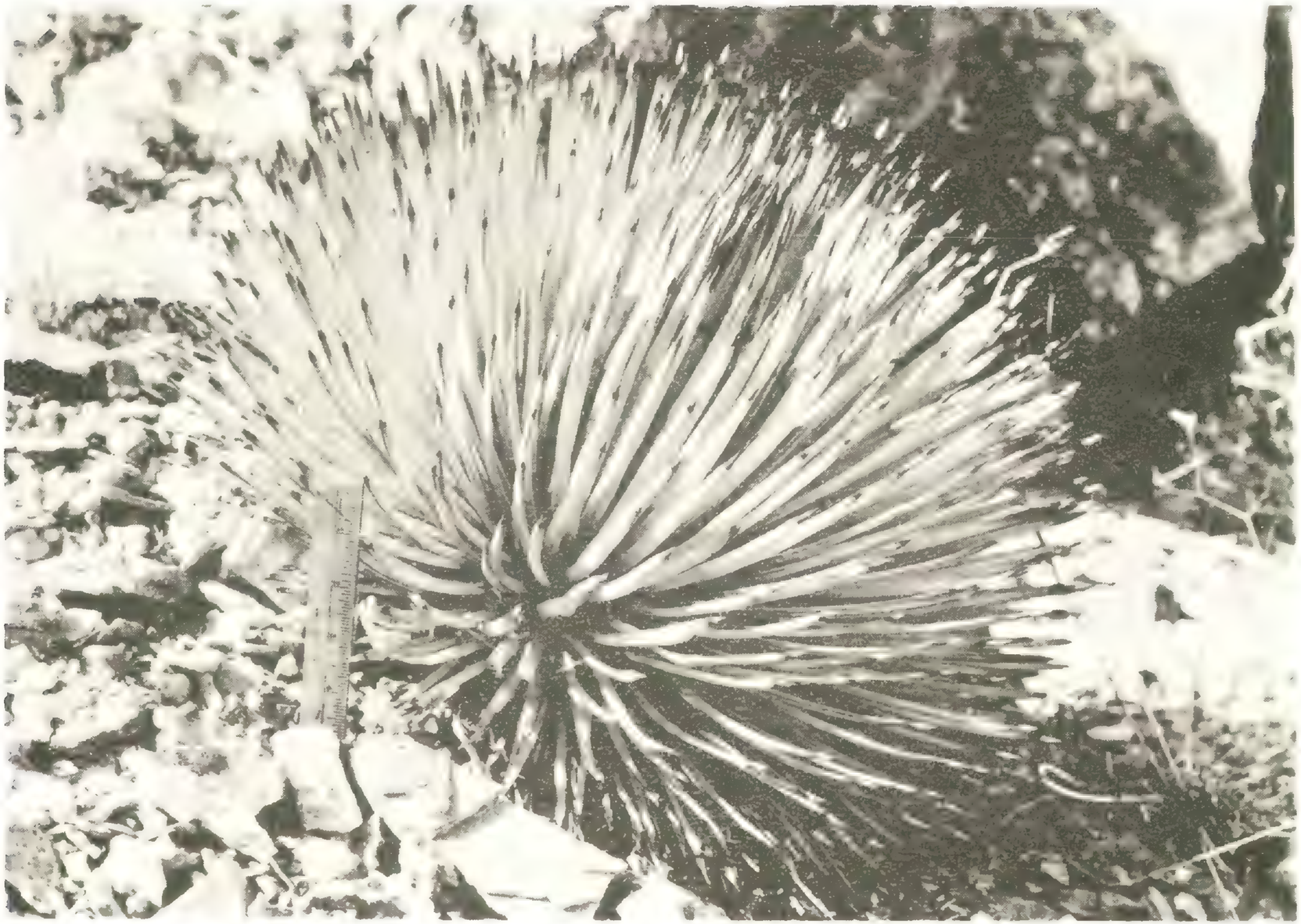
6 feet in length, slender-ovoid, the lower branchlets about 6 inches long, the uppermost 3 - 4 inches, the tip racemose for about 8 inches.

The slopes of the Canyon were searched with field-glasses but no flowers were discovered. The Indian guide felt that, in view of the mild winter, the plants should have been in bloom if flowers were to be produced in the current year. He stated, and it appeared to be the case, that the plant never is found on the mesas above but always below the Canyon rim, descending thence to the base of the gorge. The elevation at New Water Point is approximately 5000 feet, the Colorado some 4000 feet lower.

How far to the east and west along the river *Yucca Whipplei* may be found is not known; the author has never heard of its occurrence on the much-botanized south side of the Grand Canyon proper to the east, nor was it seen to the west in the Boulder Dam region or at the crossing of the Colorado at Searchlight; nor could search or inquiry offer encouragement as to its possible presence on the north side of the Colorado, certainly in so far as the Kaibab Forest region is concerned. The plant would appear to be confined to the southern side of the river and to extend for no great distance, in the southwestern use of the term, either to the east or west of the regions visited. It is unfortunate that this interesting extension of range may eventually be obliterated.

ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

MATURE PLANT OF YUCCA WHIPPLEI



SMALL PLANT OF YUCCA WHIPPLEI GROWING AT NEW WATER POINT

VIEW WEST FROM NEW WATER POINT SHOWING THE LOWER GRANITE GORGE OF THE COLORADO

VIEW NORTH SHOWING DIAMOND PEAK. BEYOND FLOWS THE COLORADO

A KARYO-SYSTEMATIC STUDY OF ROBINIA

THOMAS W. WHITAKER

With one text figure

THE GENUS *Robinia* contains about 20 species, and has a strictly North American distribution. Furthermore, it is practically confined to the continental United States; only one species has been recorded from territory outside of this area. An interesting feature about the distribution of this genus is the parallel course it runs east and west of the continent. Thirteen species are found in the Appalachian Mountains from Pennsylvania southward to Georgia and Alabama, and five species are found in the Rocky Mountains from Colorado to as far south as the Mexican border (Rydberg, 1924).

As one of the steps necessary in supplying a biological background for a systematic study of the genus, a karyological investigation has been undertaken of the species of *Robinia* in the collections of the Arnold Arboretum. Although this collection is by no means complete, it contains representatives of each series of the genus, and from this point of view the species examined furnish a general survey of the karyological conditions in *Robinia*. A brief report of the karyological observations and comments on their systematic significance follow.

OBSERVATIONS

Robinia is decidedly not ideal material for karyological studies. The chromosomes are small, and in aceto-carmine smears the differentiation between chromatin and cytoplasm is not particularly sharp. Heating does not alleviate this condition as it does with some material. The chromosome counts were secured from aceto-carmine, and in some cases permanent smears. In Table I the chromosome number and percentage of pollen sterility are recorded for the species that were investigated.

Ser. PSEUDOACACIAE and NEO-MEXICANAE

Tschechow (1930) has published a figure (from mitosis in a root-tip cell) in which *Robinia Pseudoacacia* is shown to have 22 chromosomes. Kreuter (1930) has found 10 chromosomes at meiosis in this species. The present writer did not have material available for study, but from indirect evidence, one is forced to the conclusion that there must be 10 pairs of chromosomes in this species. This conclusion is based on the observations of meiosis in spontaneous hybrids where *R. Pseudoacacia*

was reputedly one of the parents; i. e. *R. Holdtii, R. Slavinii, R. Margaretta*. Since the other supposed parent in most cases has 10 pairs of chromosomes, with normal pairing taking place, the evidence favors the view of Kreuter that *R. Pseudoacacia* has 10 pairs of chromosomes.

TABLE I

	Species	Chromosome number (n)	% pollen sterility
I. PSEUDOACACIAE	R. Pseudoacacia L.	*10	25
	R. Holdtii Beissn. (R. Pseudoacacia × R. luxurians)	10	16
	R. fertilis Ashe	10	19
	R. Kelseyi Hutchins.	10	10
II. HISPIDAE	R. hispida L.	15	88
	R. Boyntonii Ashe	15	72
	R. Slavinii Rehd. (R. Kelseyi × R. Pseudoacacia)	10	48
	R. Margaretta Ashe (R. hispida × R. Pseudoacacia)	10	30
III. NEO-MEXICANAE	R. luxurians Schneid.	10	25
	R. viscosa Vent.	10	45
IV. VISCOSAE	R. Hartwigii Koehne	10	10

*From Kreuter (1930)

Robinia Holdtii (*R. Pseudoacacia* × *R. luxurians*) has 10 pairs of chromosomes (Fig. 1). Pairing seems to be normal; the percentage of good pollen is slightly higher than that produced by either parent. Aside from its morphological characteristics, which are intermediate between the parent species, it has few of the attributes of a hybrid.

The only western species of *Robinia* studied, *R. luxurians* has 10 pairs of chromosomes (Fig. 2). Karyologically, it is similar to the diploid eastern species. The plants of *R. luxurians* were labeled as *R. neo-mexicana*. This is undoubtedly an error. As Sargent (1921) and, later, Rehder (1927) have pointed out, *R. neo-mexicana* has probably never been brought under cultivation, and would not be hardy if it were.

Ser. HISPIDAE

In the Hispidae, *Robinia fertilis* and *R. Kelseyi* are apparently two of the basic diploid species (Fig. 3). Each species has 10 pairs of chromosomes, meiosis is regular in both species. The percentage of good pollen is relatively high and an abundance of pods is developed.

Meiosis in *Robinia hispida* and *R. Boyntonii* is very irregular (Figs. 4 & 5). This is to be expected as both are triploids. What appear to be

multivalent associations and univalents have been found at meiosis in both species. The low percentage of good pollen is a further indication that meiosis is irregular. Biologically, all of the plants of *R. hispida* in cultivation must represent a clon, since this species very infrequently produces seed pods, and since it is propagated exclusively by vegetative means. From the fact that tetraploids have thus far never been found

FIGURE 1. *Robinia Holdtii*, 10 chromosomes. FIG. 2. *R. luxurians*, 10 chromosomes. FIG. 3. *R. Kelseyi*, 10 chromosomes. FIG. 4. *R. hispida*, 10 chromosomes. FIG. 5. *R. Boyntonii*, 15 chromosomes, x and y = trivalents, z = univalent. FIG. 6. *R. Hartwigii*, 10 chromosomes. All drawings were made from first metaphase plates. Magnification: Figures 1, 2 and 4 × 2100, 3, 5 and 6 × 2500.

in *Robinia*, presumably the triploids have originated from one of the diploid species, either from an unreduced egg cell or from the fertilization of a haploid egg by a diploid pollen grain (Darlington, 1932). It seems unnecessary to assume, as Kreuter (1930) has done, that *R. hispida* is a hybrid.

Taxonomically *Robinia hispida* and *R. Boyntonii* are more closely allied to *R. fertilis* than they are to other members of the Hispidae. It is very likely that these triploid species may have originated from *R. fertilis*. The case for *R. hispida* in this respect is rather good. In many of its characters *R. hispida* bears a close resemblance to *R. fertilis*.

A spontaneous hybrid between *Robinia Kelseyi* and *R. Pseudoacacia*

has recently occurred under cultivation (Rehder, 1921). This hybrid, *R. Slavinii,* has 10 pairs of chromosomes. The pollen fertility is fairly high, and it sets a moderate crop of seed pods. Pairing seems to be normal. No meiotic irregularities were observed.

Robinia Margaretta is a reputed hybrid between *R. hispida* and *R. Pseudoacacia.* It has many of the characteristics of *R. Pseudoacacia,* and it is quite likely that the latter species may have been one of the parents. It is doubtful whether *R. hispida* could possibly have been the other parent because of its triploid nature. On the other hand, it is quite probable that *R. fertilis* may have been one of the parents. In *R. Margaretta* meiosis was regular. Pollen sterility was as high as 30%, but the plants fruited freely.

Ser. Viscosae

Meiosis in *Robinia viscosa* seems to be regular, although there is considerable pollen sterility. This species sets seeds very sparingly. Professor Rehder of the Arnold Arboretum has informed me that in some cases, trees of this species do not set any seed, indicating that in such instances pollen sterility must be much greater or that possibly the plants are self-sterile.

The two species included under the Viscosae (*R. viscosa* and *R. Hartwigii*) are very closely related. Karyologically they are similar (Fig. 6). Of the two, the percentage of good pollen is much larger in *R. Hartwigii.* This probably accounts for the fact that it sets seed in greater abundance.

DISCUSSION

The occurrence of a large number of fertile spontaneous hybrids between the various species of *Robinia* is understandable in the light of the karyological situation shown to exist in the genus. Since a majority of the species are diploids and perfect pairing exists between the hybrids investigated, most of them should hybridize readily whenever opportunity is afforded. Another point of some interest, in this connection, is that the diploid species occur in the Appalachian and on both sides of the continent and apparently hybridize quite easily. *Robinia Holdtii,* a reputed spontaneous hybrid between *R. Pseudoacacia* and *R. luxurians,* may be cited as an example. From the literature it is evident that several cases of this cross have occurred.

Kreuter (1930) and Tschechow (1930) have made extensive karyological investigations of the Tribe Galegeae. Basic numbers of 8, 10, 15, and 24 have been found. The basic number seems to be relatively constant within the genus in this tribe. There is no indication of a karyological relationship between *Robinia* and other members of the

Galegeae. *Amorpha* has a basic number of 10, but the chromosome morphology is distinctly different from that of *Robinia*.

Robinia is one of those genera in which polyploids and hybrids, even though they may be sterile, are factors to be reckoned with in speciation because of the fact that these forms are propagated very readily and rapidly by vegetative means, and are thus able to maintain themselves.

SUMMARY

The basic chromosome number in *Robinia* is 10. *Robinia hispida* and *R. Boyntonii* are triploids. These species are maintained by vegetative means. The chromosomes in all of the hybrids exhibited complete compatibility. This is true of the hybrids between the eastern and western species of the genus, which have been separated by considerable periods of geologic time.

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A CULTURE CHAMBER FOR THE STUDY OF MYCORRHIZAE

A. B. HATCH

With two text figures and plate 118

THE EXACT NATURE of mycotrophic relationships still remains unknown. A first essential of investigation in this field is the development of suitable experimental methods. Among these an outstanding requirement is that of establishing and maintaining pure cultures. The usual apparatus for this purpose is cotton stoppered flasks but the physical environments in these are optimal for neither host nor fungus and extraneous factors that affect the accuracy of results are not eliminated. A culture chamber that meets these requirements has been developed by the writer and is described below.

Factors which affect unfavorably the accuracy of experiments in the apparatus commonly employed include: (1) excessive humidities which promote aërial growth of fungi which in nature are confined to roots only (Melin, 1925; Masui, 1927; Rayner, 1925, 1930; McArdle, 1932; Hatch and Hatch, 1933), (2) increased partial pressures of carbon dioxide in inoculated cultures produce corresponding increases in plant growth but in a manner wholly unrelated to mycotrophy, (3) accumulation of products (in some cases toxic) of fungal metabolism and of unabsorbed ions in substrates that cannot be changed (Melin, 1925), (4) saturated substrates—when fine quartz sand is employed (Rayner, 1930; McArdle, 1932), (5) low radiation intensities resulting in low rates of carbohydrate synthesis.

It is generally believed that if mycorrhizae are beneficial, they must be *accessory* mechanisms only, and by most investigators on this subject they are thought to be concerned with acquisition of nitrogen from infertile substrates. In the closely allied field of nitrogen-fixing, bacterial root-nodules it is known that these accessory mechanisms are called forth under internal conditions of wide carbohydrate/nitrogen ratio only (Fred and Wilson, 1934). The necessity of maintaining rapid rates of carbohydrate synthesis by increasing partial pressures of CO_2, by high radiation intensities, or by both, is evident.

Finally, to be conclusive the data should be quantitative and this involves the growing of large numbers of plants—a task of large proportions in ordinary chambers (McArdle, 1932).

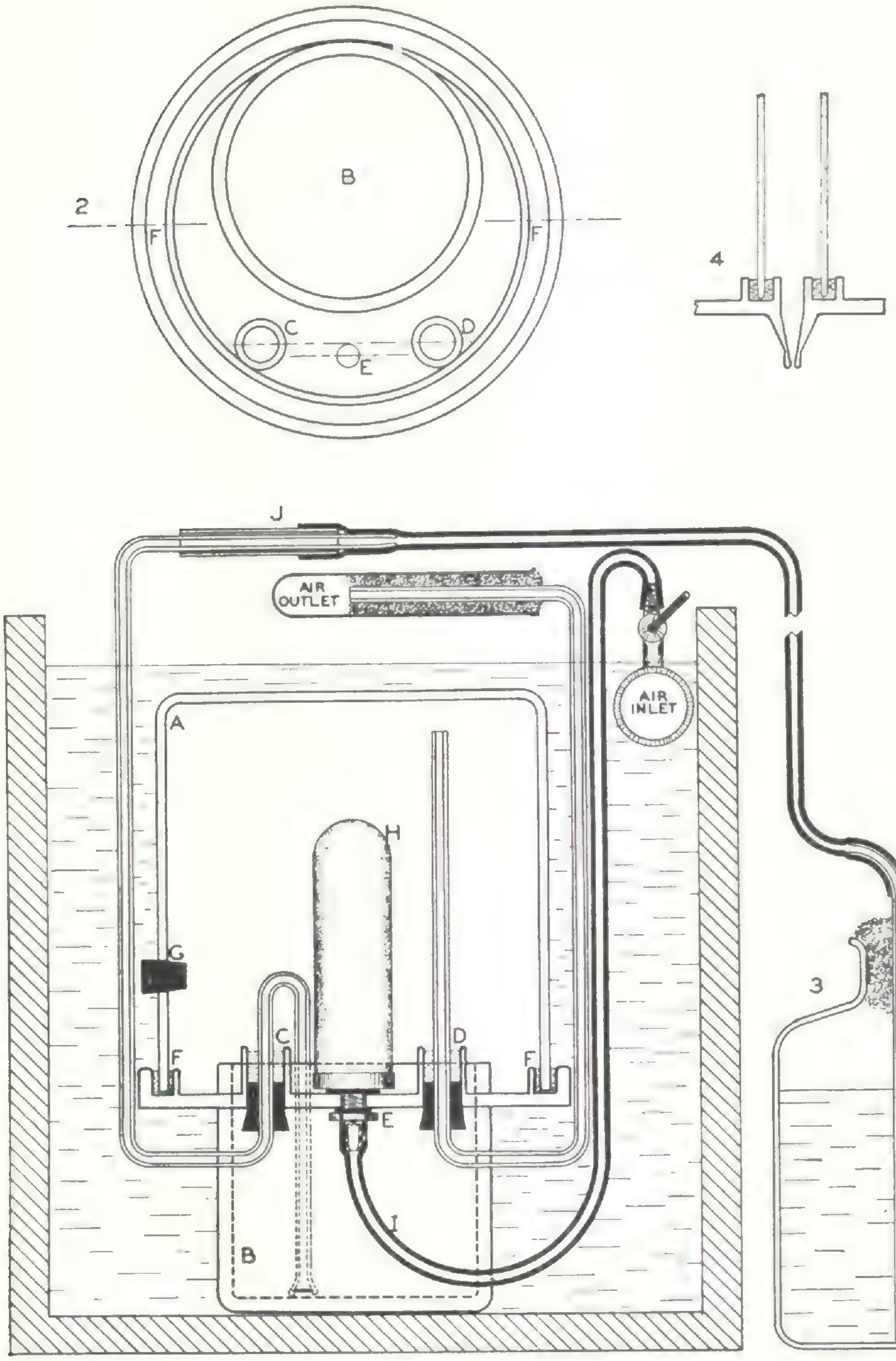

FIGURE 1. Pure culture chamber with 10 × 10⅛ inch bell jar. 1. Schematic drawing of intact chamber in water bath. 2. Plan of porcelain base. 3. Nutrient flask. 4. Structure of alternative base for open-end filter. (Drawings by Robert Ward and the writer.)

To avoid these inaccuracies an apparatus has been developed which facilitates the following: (1) continuous aëration (control of gas composition and moisture content), (2) periodic flooding and aërating of substrate, (3) frequent changes of nutrient or water, (4) exposure to direct solar or artificial radiations of the highest intensities, (5) temperature control, by means of a constant temperature water bath, and (6) indefinite freedom from contamination.

The plant chamber of this apparatus consists of a glazed clay base (my early models had copper bases—see plate 119) through which are inserted all connections and over which is cemented a Pyrex cylinder jar (Fig. 1,[1,A]). The base possesses a substrate well B and a circular platform through which are three openings C, D, and E. Openings C and D are identical, having inside diameters of approximately 2 cm. and heights of 4 to 5 cm. Through these openings heavy-walled pyrex tubes are inserted; one (through C), for changing nutrients, extends to the bottom of the substrate well; the other (through D), for air escape, extends within the chamber to a position near the top of the bell jar opposite the air inlet filter H (in the figure shown in a vertical position). Opening E is for inserting the air filter H, and may be of two types: a plain hole through which a Berkefeld, grade V, water filter is sealed with rubber washers, as shown in the main drawing; or a trough is built around the filter opening and an open base filter is cemented into it during sterilization (Fig. 1,[4]). (The open base filter and suitable chamber base are much less expensive.)

The circular "platform" possesses a trough F around its margin, into which the cylinder jar is cemented. As indicated in Fig. 1, [2,B], the substrate-well is off-center to give space for the three openings C, D, and E. In existing samples of the clay base chamber the glaze has not been wholly satisfactory; accordingly, a pyrex cylinder jar of small size (6 × 6 inches) has been wedged inside of the well to serve as the actual substrate container (see plate 118, which shows this jar in the metal base chamber).

The upper half of the chamber, as indicated, is an inverted pyrex cylinder jar with a 17 mm. opening G through its wall for inoculating and for introducing germinating seeds (approximately 75 mm. above the bottom rim).

The position of the nutrient changing, and air outlet tubes (extending through C and D) on the outside of the chamber is determined by convenience and the method used in maintaining the chamber at a constant temperature. Their positions in Fig. 1,[1] are adapted for complete immersion of the chamber in water.

Sterilization of the chambers may be by steam or by hot air, each of which involves separate consideration.

With steam sterilization, either a Berkefeld filter with rubber seals or the open ended type may be employed, and also rubber stoppers for holding tubes C and D in place as shown in Fig. 1,[1]. Cotton is placed in the inoculation opening of the glass jar and over the outside ends of the tubes through C and D. The base, with sand substrate, and the cylinder jar are then sterilized separately for three hours at one atmosphere; the pressure is allowed to escape quickly; DeKotinsky cement, which has been previously stretched to a suitable thinness, is placed in the spaces above the rubber stoppers in C and D and completely around the trough E, into which the glass jar fits, and also in the filter trough (Fig. 1,[4]) when the open-base filter is used. The intact chamber is then ready for immediate resterilization for 25-45 minutes. Such heating periods are sufficient for killing any organisms which enter during these manipulations and yet are not so long that the strength of the cement is destroyed. A perfect seal is obtained during this final sterilization and by ordinary careful handling the chamber may be kept for months or perhaps years without danger of contamination. Since DeKotinsky cement is slightly soluble in water, all surfaces that come in contact with water in the constant temperature bath should be protected, preferably with picein.

With hot air sterilization, rubber connections must be replaced by cork or other material. The Berkefeld filter is also awkward in this method and the open-base filter (Fig. 1,[4]) must replace it. An advantage of hot air sterilization is that picein cement, which is less expensive than DeKotinsky and also insoluble in water, may be employed. In steam sterilization picein is not suitable, since its specific gravity is less than water and condensing steam prevents the sealing of joints. If chambers of the larger sizes, for agricultural plants, are used (30 $\times$ 14 inches) hot air is most suitable, unless large soil sterilizers are available.

Surface sterilized seed and fungal cultures are inserted through the inoculation opening G while the chamber is in a transfer room. This opening is then sealed with a rubber stopper and picein cement or with the latter alone.

Aëration of the chamber is accomplished preferably by air pressure, but precautions should be taken that such air is free of oil and other impurities and that a proper humidity is maintained (see Shelford, 1925, for suitable equipment). Rates of air passage up to several liters per minute are obtained by Berkefeld 5 $\times$ 15 cm. V filters with pressures of 3-5 cm. of mercury. The open-base filters are less porous and

greater pressures are required for comparable air passage. A rubber tube I should be cemented to the base of the filter-opening before immersion.

The nutrient reservoir consists of a 4-liter, or larger, pyrex or Jena glass bottle with a cotton stopper through which is inserted a glass tube (Fig. 1,[3]). Heavy walled rubber tubing connected to this glass tube extends over a 12 mm. tube of 10 cm. length (Fig. 1,[1,J]). After the culture flask and contained nutrient or water are sterilized, this nutrient changing tube and the tube passing through C are thoroughly flamed and brought together so that the smaller tube extends a few centimeters into the larger one of the nutrient flask (J). After cooling to a point where the rubber will not be injured, they are firmly connected. Except for the latter mode of connecting the nutrient supply to the culture chamber, this siphon tube method of changing nutrients in pure culture was developed by Dr. K. D. Doak at the University of Pennsylvania, only an abstract of whose work is now available (Doak, 1934). In its present form it has been regularly employed by Dr. Doak as well as by the writer for several years without a single contamination being traced to its use.

To flood the substrate the siphon is started by cupping one's hand over the cotton stopper of the nutrient flask and blowing. Subsequent raising and lowering of the nutrient flask floods and drains the substrate. The nutrient supply flask may be disconnected (at J) with entire safety and replaced by a fresh nutrient or water supply at any convenient intervals. With exposure to direct solar radiation the rubber tubing should be replaced every few months.

In early experiments air cooling of the chambers during exposure to direct solar radiation proved to be inadequate. The subsequent combination of air cooling and water cooling (of the substrate well only), although fairly effective, was difficult to handle and air temperatures varied. Finally, complete or partial immersions of the chambers in an approximately constant temperature water tank proved to be entirely satisfactory (Fig. 1,[1]). By this method high radiation intensities, both artificial and solar, are usable. The most exacting requirements of temperature control are also possible.

Standard, heavy walled, pyrex cylinder-jars are available in sizes ranging from 6 × 6 in. up to 12 × 24 in., with many intergradations. Agricultural plants of comparatively large statures (potatoes, tomatoes, grains, etc.) may therefore be grown to maturity in chambers of this design under pure culture conditions and in optimum environments.

The chamber has the disadvantage that roots may not be observed during the course of the experiment. An all glass chamber of the type shown in Fig. 2,D, possessing a flattened substrate tube, has been con-

structed to supplement the lack of this feature in the larger chamber. These chambers are made of Florence flasks of any desirable size. By starting plants in them simultaneously with those in the large chamber, and under the same nutrient conditions, the probable course of development of mycorrhizae in the larger chambers may be predicted. This chamber is also immersed in the water bath. Although air change is not

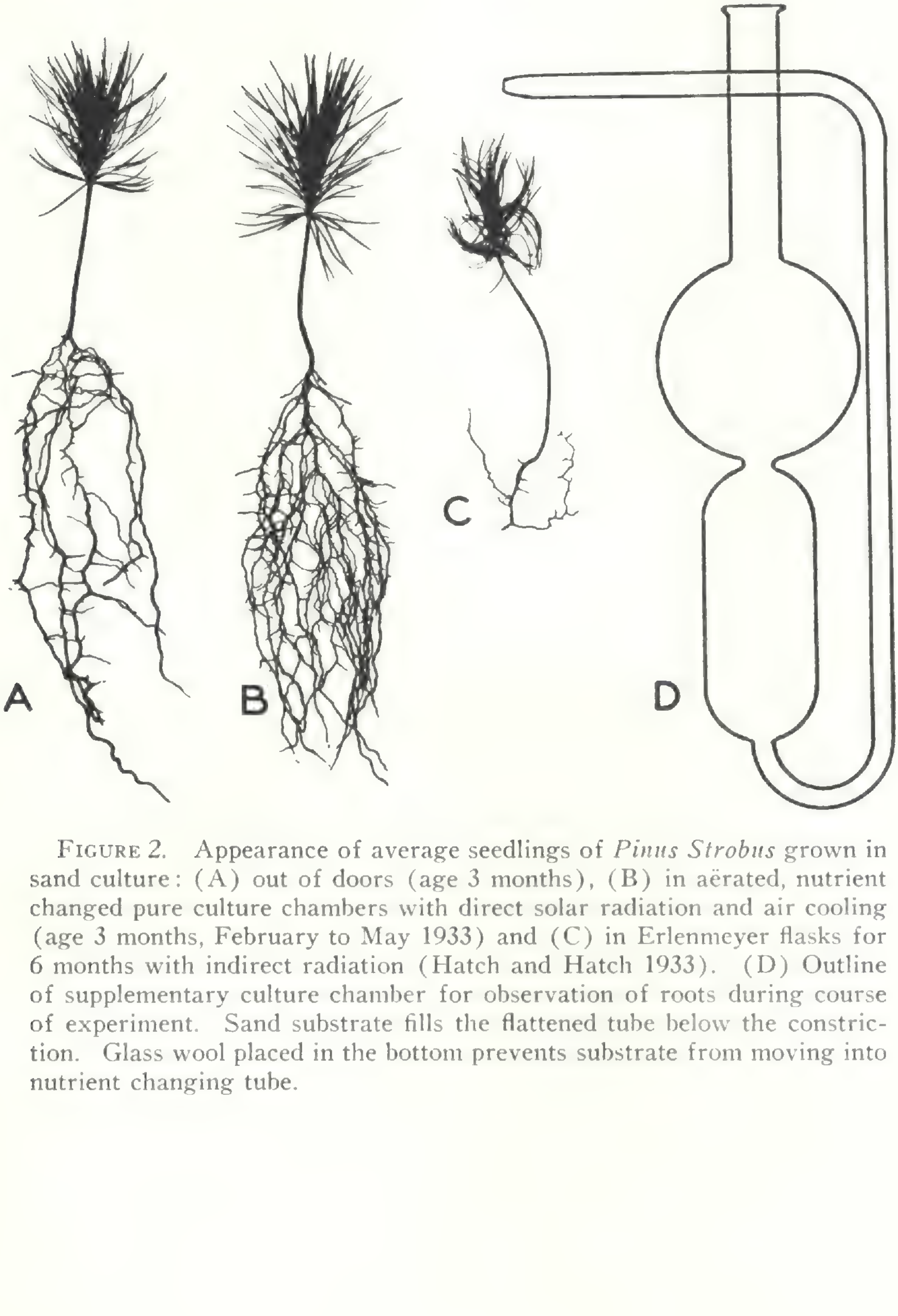

FIGURE 2. Appearance of average seedlings of *Pinus Strobus* grown in sand culture: (A) out of doors (age 3 months), (B) in aërated, nutrient changed pure culture chambers with direct solar radiation and air cooling (age 3 months, February to May 1933) and (C) in Erlenmeyer flasks for 6 months with indirect radiation (Hatch and Hatch 1933). (D) Outline of supplementary culture chamber for observation of roots during course of experiment. Sand substrate fills the flattened tube below the constriction. Glass wool placed in the bottom prevents substrate from moving into nutrient changing tube.

continuous the siphoning of nutrients in and out facilitates a material improvement in the aërial environment over ordinary enclosed flasks.[1]

The types of tree seedlings (*Pinus Strobus* L., 3½ months old) that may be grown in the large chambers are shown in Fig. 2,B. They are quite comparable in size, root shoot ratio, root development, and succulence to those grown in open cultures under direct solar radiation out of doors (Fig. 2,A). An average seedling 6 months old grown in Erlenmeyer flasks is shown in Fig. 2,C.

Development of this apparatus was commenced during the writer's period of study with Professor E. Melin in the mycological laboratories of the Royal Forest Academy, Stockholm, Sweden, in 1930 as Fellow of the American Scandinavian Foundation. The work was continued with the United States Forest Service at the Boyce-Thompson Institute for Plant Research and was finally completed at Harvard University, where the greater part of the work was done. The writer is grateful for the facilities and support of these institutions and to their staffs for advice.

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[1]Both chambers complete with all accessories (cement, tubes, stoppers, filters, etc.) are supplied by MacAlaster-Bicknell Co., Cambridge, Mass. Bases for the 10-inch-bell jars are in stock; all other sizes are made to order.

SEEDLINGS OF PINUS STROBUS GROWN IN THE CULTURE CHAMBER

EXPLANATION OF PLATE 118

Seedlings of *Pinus Strobus* L. grown in aërated, nutrient-changed, air cooled pure culture chamber (metal base type) with full solar radiation (February–May 1933), 3½ months old. × 7/12. Bell jar removed for photograph.

LABORATORY OF PLANT PATHOLOGY, ARNOLD ARBORETUM,
THE HARVARD FOREST, AND THE DEPARTMENT OF BIOLOGY,
HARVARD UNIVERSITY.

THE ARNOLD ARBORETUM DURING THE FISCAL YEAR ENDED JUNE 30, 1934

THE WINTER OF 1933-34 was the worst ever experienced in the Arboretum. Beginning as early as December 29th, 1933 the thermometer went as low as 17 below zero. The maximum that day was 4 below. The latter part of January, the thermometer was 2 below with no snow on the ground and heavy winds. From February 7th to 10th the temperature varied from 2 below to 18 below. Practically no snow fell until February first.

These variable conditions caused untold injuries to trees and shrubs, killing flower buds and some plants to the grounds. From early spring to June, considerable time was spent in pruning out dead wood and cutting plants to the ground.

Four hundred and ninety-nine plants were added to the Arboretum collections. Two hundred and ninety-one plants were transferred from the Arboretum nursery to South Street Nursery.

During the year, 1712 packages of seed were sent out, 616 in United States and 1096 to 21 foreign countries, 2358 plants and 422 varieties of scions and cuttings. There were received from U. S. and other countries 1105 packages of seed, 1286 plants and 35 cuttings and scions. — L. V. S.

Pathological Laboratory.—The Arboretum's research laboratory in Plant Pathology submits its report for 1933-4, dealing in order with its herbarium, extension services and investigative activities.

The herbarium is essentially restricted to reference collections used in the study of diseases of trees and shrubs. These illustrate symptoms and effects of diseases, causal organisms, and injuries that result from unfavorable physical and chemical environmental factors. Much material has been added during the year. Some specimens have come from correspondents asking for diagnoses, some from other herbaria by way of gifts or exchanges, and many have been collected by members of the staff. Besides exceptionally important local contributions, valuable accessions have come from Japan, Leningrad, Jamaica, the Canal Zone and the Republic of Panama. Attention should again be called to the fact that adequate space for the pathological herbarium has never been provided, and that such as there is has been completely outgrown. Indeed, more than a year ago it was necessary to store elsewhere with crippling effect an entire section involving several thousand numbers.

Use of the extension services afforded by the laboratory continues to show a steady expansion. Inquiries on pathological problems, usually accompanied by specimens, are received from private individuals, nurserymen, arborists, city and town tree wardens, foresters, landscape architects, etc. Such contacts occasionally lead to co-operative undertakings. At the present time experimentation is being carried out by joint arrangement with a few estate owners, two nurseries, a garden club and a state experiment station. On account of well-founded and widespread fears that the Dutch elm disease might spread northward from southern Connecticut, where it is now known to occur, an exceptionally large proportion of inquiries this year have related to elm diseases. From the time of the first report of the discovery in 1930 of the Dutch elm disease in America the Arboretum made preparations to assist in combating it. The very earliest cases were examined in this connection by the head of the department and attention was immediately given to the study of elm diseases, and to acquainting the public in New England with the nature and the seriousness of the disease. Thus a free, voluntary service has been provided apart from but in full sympathy with the aims and efforts of the Federal Bureau of Plant Industry whose laboratory is located at Morristown, New Jersey. In the matter of publicity important work is being done by the Massachusetts Forest and Park Association, an organization with which the Arboretum is co-operating in meeting the new menace to our elms.

Turning to our research activities mention should be made of certain pieces of sustained investigation that have now found expression in printed papers. Dr. John Ehrlich's pioneer studies on the beech disease caused by a *Nectria* following attacks of an introduced bark insect have been issued jointly by the Arnold Arboretum and the Canadian Research Council, by the former as Contribution No. VII and by the latter in a special number of the Canadian Journal of Research. The first part of Dr. Ivan H. Crowell's studies on *Gymnosporangium* appeared in the July (1934) issue of the Journal of the Arnold Arboretum under the title "The Hosts, Life History and control of the Cedar-Apple Rust Fungus Gymnosporangium Juniperi-virginianae Schw." This fungus long known as a parasite alternating between certain orchard apples and red cedars, and recognized as the cause of a destructive disease of the orchard apples and a pest on the red cedars was studied by Dr. Crowell in relation to all known species of apples and a large number of species of *Juniperus*, and to its control by methods other than eradication of red cedars. As a result of an exhaustive series of inoculations it was discovered that all American species of apples are susceptible and all of

Eurasian origin, with the exception of two highly resistant forms, are immune. Similar data were obtained for the red cedar group. Notably, tests of certain sulphur fungicides point the way to successful control without having recourse to the elimination of either host. Professor J. H. Faull has added another chapter to our knowledge of a group of rusts that alternate between firs and ferns—a study of the biology in general of these rusts and completed data on the life histories of several American species.

As indicated above comprehensive studies are now in progress on elm diseases. Part of the field work on these is being done in connection with an auxiliary laboratory opened up on Long Island through the enterprise of Mrs. Harold I. Pratt and the generous support of friends of the Arboretum. Other topics under investigation include various diseases of conifers, the physiology of the mycorrhizae and pseudo-mycorrhizae of pines, rust diseases of the hawthorns and certain other pomaceous hosts, a physiological disease of apples, and a monographic study of *Uredinopsis*.—J. H. F.

Cytogenetic Labcratory.—The work in cytology during the past year has included studies on chromosome structure and the mechanism of meiosis. The examination of Tradescantia chromosomes, after being subjected to various temperatures, and treated with X-Rays, has thrown considerable light on the internal structure of chromosomes, their method of pairing at meiosis, and the factors involved in cell division. The effect of environmental factors on chromosome pairing at meiosis may be an important factor in genetic variation and evolution.

The cytological analysis of taxonomic groups of plants has been continued, especially in the gymnosperms. With the co-operation of Dr. Beal of the University of Chicago, it has been possible to obtain chromosome counts in the cycads. This work, with the analysis of conifer chromosomes completed last year, permits a comparison of the more important groups of gymnosperms. Dr. Whitaker has found an unusual and characteristic chromosome number in a number of rather distantly related monocotelydons. A number of leguminous plants have been examined during the past summer.

Other lines of cytological work in progress include studies on the mechanism of development and differentiation, parthenogenesis, and self-sterility.

The breeding work was rather limited owing to the effects of the severe winter. Some of the hybrids between species of ornamental shrubs should flower in another year.—K. S.

The Herbarium.—During the past fiscal year 16923 specimens have been added to the herbarium bringing the total number up to 391803.

Of these accessions approximately 800 came from the United States and Canada, 825 from Central and South America inclusive of Mexico, 650 from Europe and western Asia, 6000 from China, 600 from Formosa and Japan, 670 from India, 3000 from Sumatra and Borneo, 250 from Australia and Micronesia and 500 from Africa.

Among the more important collections received during the year may be mentioned: 783 specimens from Paraguay collected by Pedro Jorgensen, 790 specimens from Honduras, including duplicates, collected by J. B. Edwards; 327 Brazilian specimens collected by B. A. Krukoff; about 600 Mediterranean plants collected by J. Bornmueller with many duplicates; a collection of 260 specimens of *Tilia* issued by J. Wagner; about 2400 specimens including duplicates of Hainan plants from the Lingnan University; about 1200 specimens including duplicates of Kwangsi plants from the University of Nanking; 600 specimens of Anwhei plants from Wuhan University; about 700 specimens of Szechuan plants from the Science Society of China; about 700 specimens of Yunnan plants collected by J. F. Rock from the University of California; about 1270 specimens from Sierra Leone collected by W. N. Thomas; 425 specimens from South Africa collected by Ecklon and Zeyher; about 2500 specimens from Borneo collected by J. & M. S. Clemens.

To the fruit collection 169 specimens were added bringing the total number up to 7984.

Additions of 815 numbers were made to the wood collection bringing the number up to 3631.

The collection of negatives of types and critical specimens amounts now to 2744 negatives; 220 having been added during the year.

On loan for study outside the Arboretum herbarium 312 specimens were sent to 19 institutions and individuals in this country, in Europe and Asia.

There have been distributed 20140 specimens to 33 institutions in the United States, Canada, Europe, Asia, Africa and Australia.

Botanical exploration by members of the staff or by expeditions partly financed by the Arnold Arboretum has been carried on in America and in Eastern Asia. Dr. H. M. Raup studied during the summer of 1933 the flora at and near the Harvard Forest at Petersham and collected herbarium material. Mrs. Susan Delano McKelvey travelled in the spring of 1934 in New Mexico, Arizona, Nevada, Utah and Colorado, collecting about 1000 specimens with many duplicates; of these 135

numbers represented *Yucca* (dry material, material in formaldehyde, moths and photographs), and 25 numbers *Agave*. The desert because of the drought was almost devoid of bloom, only at the higher elevations were conditions more normal. Mr. E. J. Palmer collected in June 1934 in the southern states paying particular attention to *Crataegus* and studied Beadle's and Ashe's types of this genus in the National Herbarium and in the herbarium of the University of North Carolina. Mr. C. H. Mueller started in the beginning of May 1934 on a collecting tour to northern Mexico for the Arnold Arboretum with the support of the University of Texas.

In China botanical expeditions by three institutions had the financial support of the Arnold Arboretum during 1933. An expedition under the direction of Dr. A. N. Steward from the University of Nanking collected in the province of Kwangsi. By the Lingnan University in Canton three expeditions under the direction of Dr. F. P. Metcalf went to the provinces of Kwangsi, Hunan and to the island of Hainan. An expedition from the Fan Memorial Institute of Biology at Peiping under the direction of Dr. H. H. Hu collected in western China.—A. R.

The Library.—During the past year there have been added to the Library 571 volumes, 400 pamphlets and 346 photographs, making a total of 41,490 bound volumes, 10,485 pamphlets and 17,241 photographs. Many of the additions have been acquired by gift, among them "The Stapelieae" from the author, Alain White; Thomas Horsfield's "Experimental Dissertation on the Rhus vernix, Rhus radicans and Rhus glabrum," 1798, from C. C. Deam; Zhukovsky's "La Turquie Agricole," and "Rastenievodstvo SSSR," from the Institute of Plant Industry at Leningrad; "Report of the Second Norwegian Arctic Expedition in the 'Fram,'" 1898-1902, from the Universitetets Farmasøitiske Institutt, Oslo; and "Letters of Asa Gray," from Katharine P. Loring; together with a large number of pamphlets from Japan, China, Sweden, Germany and Russia. A photostat copy of "Versuch einer Neuen Lehrart die Pflanzen nach Zwei Methoden zugleich," by F. K. Medikus, 1787, was presented by the Herbarium.

Fifteen periodicals, chiefly from Russia, China and Central Europe, have been added during the year, while a few periodicals previously received, but taken in other departments of the University or in neighboring libraries, have been discontinued to avoid unnecessary duplication. Two sets of periodicals, "Gummi-zeitung," volumes xxii-xlvii, and "Gummi- und Asbest-zeitung," volumes vii-xxxii, were transferred to the Baker Library of Harvard University School of Business Administration.

Cards filed during the year include 836 in the card catalogue of books in the Library, 458 in the catalogue of photographs, 4,918 in the "Card-Index of New Genera, Species and Varieties Published by the Gray Herbarium," and 3,411 in the manuscript of "Index of Illustrations and of New Genera, Species and Varieties of Ligneous Plants Published since 1915," prepared at the Arboretum, bringing the total number of the latter to 101,050. For supplements to the author and subject "Catalogue of the Library" 1,300 slips have been filed.

There have gone out as inter-library loans to universities and scientific institutions 255 volumes, and 26 volumes have been borrowed.

Volumes bound number 325, and many smaller works have been put into pamphlet binders.

The "Journal of the Arnold Arboretum" and "Arnold Arboretum Bulletin of Popular Information" were issued regularly, and numbers v and vi of the "Contributions from the Arnold Arboretum of Harvard University" were published during the year. Of the approximately 400 periodicals that come to the Library from all parts of the world 250 were received in exchange for these publications. Reprints from the "Journal" were exchanged for reprints from other publications.

The crowded condition of the stacks necessitated the addition of four new steel sections, of six shelves each, and the urgent need of the Library is still more room.—E. M. T.

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ERRATA AND ADDENDA

Page 11, line 12 from below *add*—Handel-Mazzetti, Symb. Sin. VII. 673 (1933).

" " line 5 from below strike out **Synon. nov.**

" 24, line 17 *replace* comb. nov. *by* Handel-Mazzetti, Symb. Sin. VII. 682 (1933).

" 101, line 14 for *chinenese* read *chinense*.

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Synonyms are printed in *italics;* new names in **bold-face** type

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